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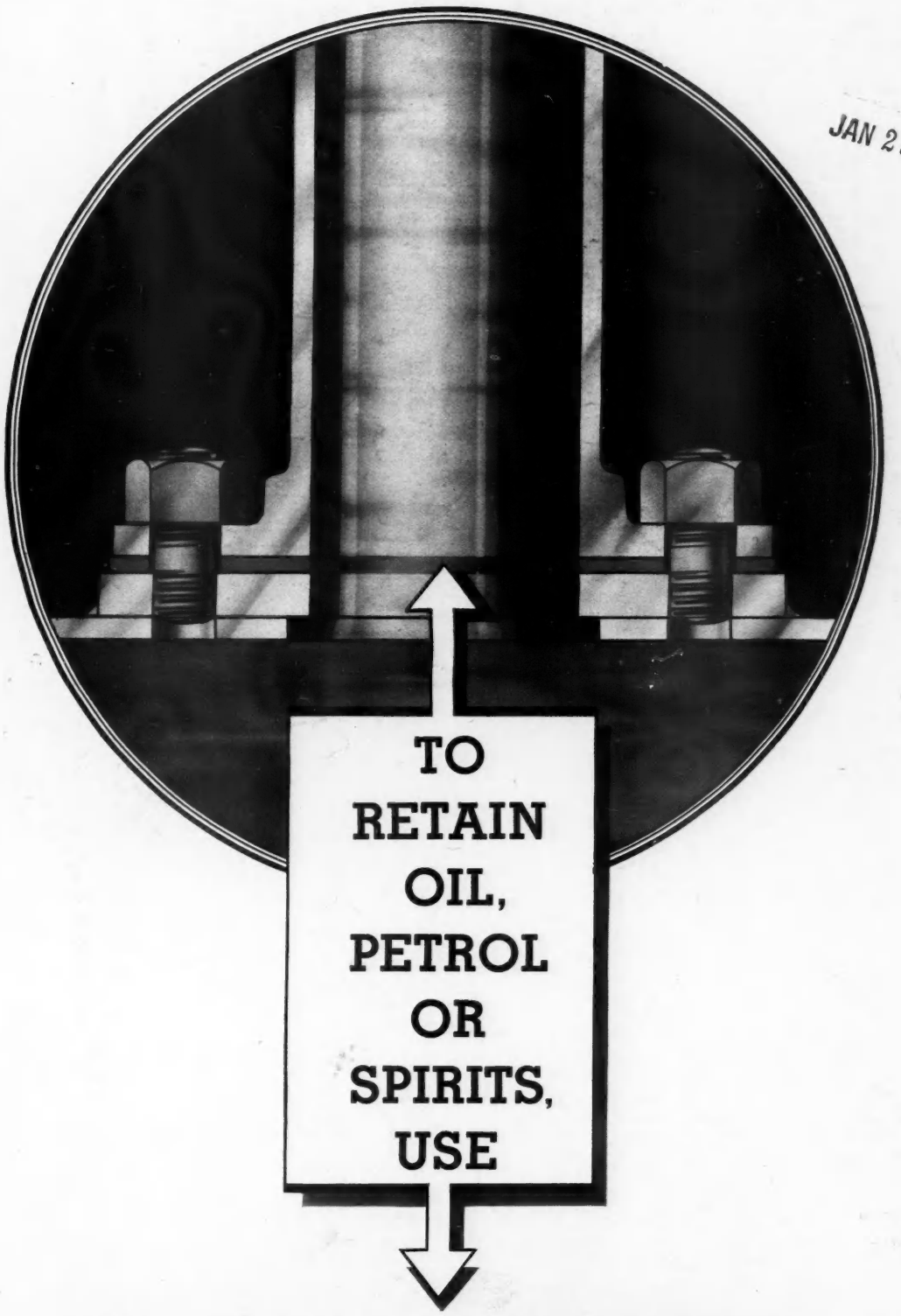


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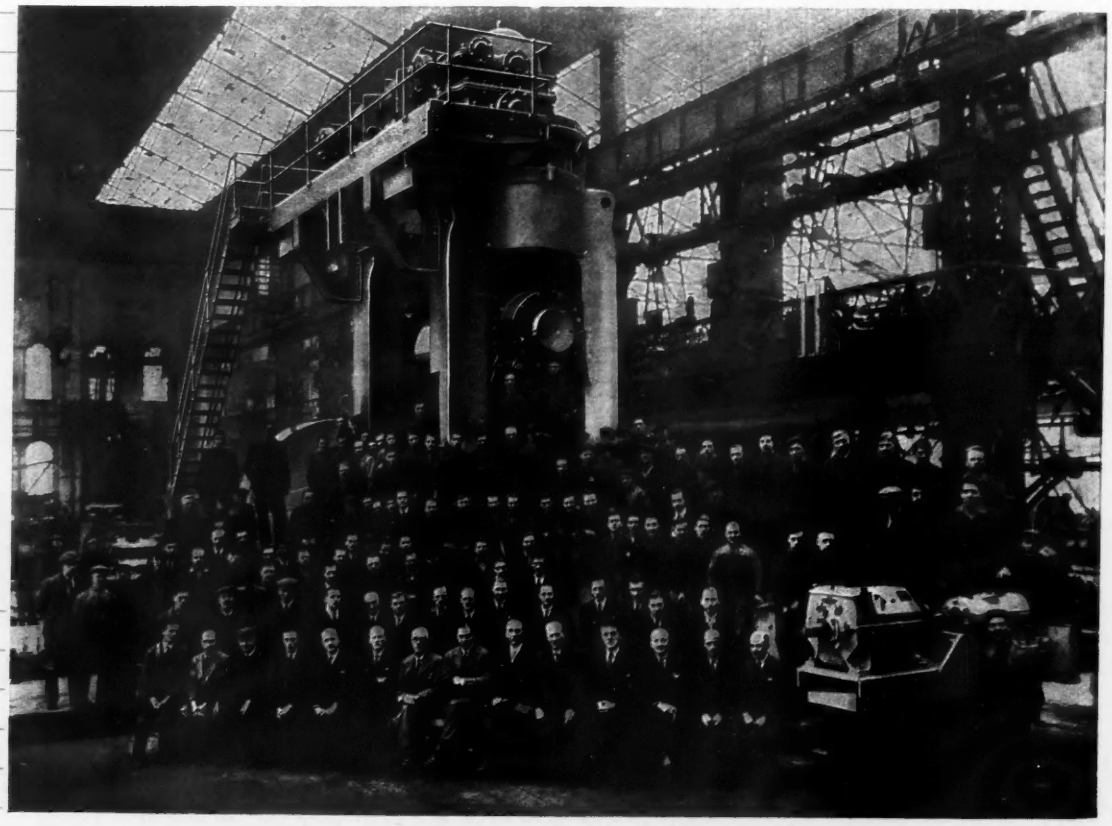

# LAMBERTON

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# A Seven-Day Journal

## Institution of Mechanical Engineers

LAST Friday, December 13th, at a meeting at the Institution of Mechanical Engineers, a paper entitled "The Physical Aspect of Steam Generation at High Pressures and the Problem of Steam Contamination," was presented by R. F. Davis. The attendance was not large. Mr. Davis being delayed, Mr. Taffs read an abstract of the paper, and on his arrival the author amplified the information then given by the help of slides. Not many took part in the discussion. It was admitted by all that the subject studied in the paper was of fundamental importance. At least one speaker, however, considered that it had been treated in so academic a manner that it would be difficult to apply the results in practice. Moreover, it was concerned particularly with large high-pressure water-tube boilers, and its results would be applicable more to vertical tube generators than to those with horizontal tubes. Similar problems were encountered in other types of boiler, and it was doubtful whether the statements in the paper would apply, for instance, to a locomotive boiler. General agreement was shown on the need for unheated downcomers, if positive circulation was to be ensured, but the criticism was voiced that the author of the paper did not seem to have taken circulation sufficiently into account. One speaker contended that to produce dry steam, control should start in the tube and not in the drum. On another page of this issue we begin to print an abstract of the paper, particularly of those sections dealing with steam generation.

## The Late Lord Vestey

THE refrigerating industry has lost an outstanding figure by the death at his home at Gerrard's Cross on Tuesday, December 10th, of Lord Vestey. He was a director of the Union Cold Storage Company and its affiliated concerns, and was joint head of the Blue Star Line. William Vestey was the son of the late Mr. S. Vestey, of Liverpool, and was born in January, 1859. He received his education at the Liverpool Institute, and when quite young went to the United States to act as a buyer for his father. Later he interested himself in the canning business, in which he was joined by his brother Edmund, now Sir Edmund Vestey, Bart. On returning from America he lived for some years at Freshfield, near Southport. He spent some time in Argentina studying the preservation of food by refrigeration, and, in conjunction with his brother, he started a cold store in Liverpool, from which operations were extended to London. From this business grew the Union Cold Storage Company, Ltd., with its allied concerns and connections in all parts of the world. About 1909 the brothers Vestey acquired one or two second-hand ships for conversion into refrigerated vessels for the transport of food from China, and from this small beginning came into being the Blue Star Line fleet of refrigerated steamers and motor vessels, which eventually became one of the largest fleets of its kind in the world, with about forty cargo and passenger ships. Lord Vestey built and operated refrigeration plants in Australia and in the Argentine. During the last war the Vestey interests placed their vast resources of stores of cattle, cold storage accommodation, and ships at the disposal of the Government. In recognition of his work, William Vestey was created a baronet in 1913 and a peer in 1922. It may be recalled that in 1924 Lord Vestey, with his brother Sir Edmund Vestey, offered to defray the cost of erection of the tower of Liverpool Cathedral, estimated to be about £220,000.

## Aircraft Production

IN a broadcast talk which was delivered on Tuesday evening, December 17th, Lord Beaverbrook, the Minister of Aircraft Production, dealt with the present position with regard to the delivery of aircraft and engines, and outlined the progress which is likely to be made in the future. He stated that in the four months of August, September, October, and November, the output of aircraft and engines was double the output of last year. That, he said, was what the aircraft industry had accomplished in the face of all the bombing, all the air raid warnings, and all the interruptions which we had suffered in public services and communications. Dealing with the supply of aircraft from America, Lord Beaverbrook said that according to the contracts we had entered into with American manufacturers, there would be an increasing flow of aeroplanes coming to us from the United States, which he estimated would reach the total of 26,000 in the year 1942. During that year the famous 3000-a-month scheme would be realised. He thought that at the present time we were over-confident, without justification. It had to be acknowledged that Hitler was still the military master of Europe, if he was not quite so much the master as he was some time ago. We had seized the control of the air by day with our fighter squadrons of Hurricanes, Spitfires, Defiants, and Whirlwinds. Now the enemy was attacking our shipping at sea, and was attempting to impose something in the nature of a blockade of Britain based on raiders, on U-boats, and on far-flying aircraft. We had to recognise that the enemy was making preparations to invade Britain even before the spring-time came. Invasion by land and sea, but principally by air. How were we going to overcome this danger? The answer was by industry, by enterprise, by endurance, and by fortitude. Lord Beaverbrook added that despite the great efforts we had made to equip our air forces in all the theatres of war, we were now in a position to supply out of our resources all the aeroplanes needed to satisfy the pilots who manned the battle line. It was a significant fact that all the fighters and all the bombers which we had lost during the four months in which the battle had raged over Britain had been paid for in full, completely and entirely, by public contributions, and the main flow of this money had come from friends overseas. Above everything else, he concluded, what we needed at present were more bombers.

## National Institute of Industrial Psychology

THE annual report of the National Institute of Industrial Psychology, published on Tuesday, shows that the early months of this, the twentieth year of the Institute's work, were shadowed by uncertainty. The outbreak of war affected its vocational guidance and educational work, and in the first few months of the adaptation of industry to war production there was little opportunity for industrial investigations. With the New Year, however, the position became clearer and brighter. An increasing number of firms turned to the Institute for advice on problems greatly intensified by the war, such as recruitment and training of staff, retraining operatives on new tasks, hours of work, the introduction of rest pauses, and working conditions in the black-out. In dealing with these the experience accumulated by the Institute in twenty years of practical work is now being recognised as of great value. The Institute has, in fact, had difficulty in dealing with all the requests for advice received, and this is now its major problem. The report gives special prominence to the rapid and effective training of industrial workers, including women. The Institute had achieved good results in this field before war broke out. Since the war it has been busy devising schemes for training operatives in various engineering and allied processes, in electrical assembly work, in power sewing machining, and in weaving. An outstanding example of results obtained in training women solderers is quoted. Dealing with hours of work, the report refers to the danger of operatives working hours so long as to be both harmful and wasteful. That danger is now becoming recognised; a word of warning is given to executives who still attempt to work fourteen hours a day, seven days a week. In spite of the conditions prevailing in London, some 450 boys, girls, men, and women have been given vocational advice by the Institute during the year. Besides that already mentioned, the work carried out during the year has included research on tests for practical constructional abilities useful in engineering. A report has also been published by the Birmingham Education Committee on vocational guidance experiments with which the Institute has been closely associated. The results have shown school leavers advised on psychological lines to be definitely better placed in industry than those advised by the usual methods. Mr. B. Seebohm Rowntree, C.H., succeeds Sir John Keane as the new chairman of the Institute.

## America's Defence Programme

IN an address given to the National Association of Manufacturers in New York on Friday evening, December 13th, by Mr. William S. Knudsen, the Member for Production in the National Defence Advisory Commission, which was quoted in Mr. Raymond Gram Swing's broadcast on Saturday evening last, some interesting figures with regard to the defence programme of America were given. The United States, Mr. Knudsen said, has undertaken an immense programme, the size of which can be measured by the following requirements:—Aeroplanes, 50,000; aeroplane engines, 130,000; heavy guns, 17,000; light guns, 25,000; trench mortars, 13,000; loaded shells, 33,000,000; tanks, 9200; machine guns and ammunition, 300,000; automatic rifles and ammunition, 400,000; regular rifles and ammunition, 1,300,000; naval ships, 318; mercantile vessels, 200; military camps and equipment, 210; Government factories, 40. In addition, clothing will be required for 1,200,000 men. This programme, Mr. Knudsen went on to say, would require in labour the incredible figure of 8 billion man-hours. Owing to the time element involved the programme was the greatest production programme of any country in modern times. At this stage, he said, the machine tool industry was the crux of the matter, and at present it was working almost exclusively for national defence requirements. To-day nearly 30 per cent. of its unfilled orders were for the aircraft production industry, while 37 per cent. were for the Army, and 28 per cent. for foreign customers, leaving only 6 per cent. to cover normal private demands. The machine tool industry was, however, not to be looked upon as a bottleneck in the sense that it was not doing its work quickly. It was sub-contracting as widely as possible in order to increase speed of production. It was estimated that three-quarters of the companies were contracting out part of their work in order to achieve quicker results. Next year there would be a considerable increase in the supply of machine tools. In concluding his address, Mr. Knudsen said that he had sought to make it clear that in his opinion the defence effort of America to date was not satisfactory enough to warrant the hope that everything was all well.

## The Institute of Fuel and the Melchett Medal

A MEETING of the Institute of Fuel was held at the Connaught Rooms on Thursday, December 12th, at which the President, Lieut.-Colonel J. H. M. Greenly, announced the award of the Melchett Medal and the Students' Medal and prizes for 1940. Preceding the meeting there was an informal luncheon, at which Mr. W. M. Selvey, who, we may recall, has been acting as President during Colonel Greenly's absence abroad, presided. The president announced that the Melchett Medal for 1940 had been awarded to Professor Etienne Audibert, of France, and he added that a strong committee in France, under the presidency of Monsieur Dautrey, the French Minister of Armaments, had recommended Professor Audibert as being the outstanding recipient. Unfortunately, however, since the disastrous happenings of last summer, the Institute had not been able to get into touch with any of its French friends, and in particular with Professor Audibert. Therefore, all that could be done was to announce the award, and to keep the medal in safe custody until it could be presented to Professor Audibert. The Institute's annual dinner, at which the Melchett Medal and the Student's Medal are usually presented, was not held this year. The Students' Medal, for the best students' paper in 1940, was presented to Mr. L. H. F. Nichols, of the research staff of the British Coal Utilisation Research Association, for his paper, entitled "Gas Sampling and Temperature Measurement in the Fuel Bed." The medal was accompanied by a prize of books. A special prize, consisting of books, was presented to Mr. H. Buckley, a member of the staff of the Paterson Engineering Company, for a paper which the adjudicators had considered to be very well worthy of a second award.

## Buenos Ayres Great Southern Railway

IN the course of his chairman's address at the 122nd ordinary general meeting of the Buenos Ayres Great Southern Railway Company, which took place in London on Wednesday, December 11th, Sir Follett Holt, K.B.E., M. Inst. C.E., said that in spite of the war conditions and a poor wheat crop in Argentina, the Great Southern Railway had carried the usual immense amount of traffic. That had included 57,000,000 passengers, 340,000 tons of parcels and other traffic, which included nearly 10,000,000 head of livestock. While the total work was greater than that of the previous year, the receipts were less. They were, however, far more than counterbalanced by the restrictions in expenditure. One burden the company had had to carry was the depreciation of the peso, which last year had cost it £1,086,000. Competition with road traffic still had to be faced, but rates here and there were in course of adjustment to counteract it, and better and more economical service was now being given by the new oil-engine-driven railcars. With regard to the future of the railway, Sir Follett Holt mentioned that the war, with its demand for minerals, was causing more interest to be taken in the hidden resources of the Andes. Even coal was now being mined at the rate of 1000 tons a month, and was being transported long distances by road to the railway company's station at Zapala. There was no doubt, he said, that Argentina possessed, among other good things, immense latent mineral wealth from gold downwards. Following the purchase of the Central Cordoba Railway by the Argentine Government, projects had been mooted by Members of Congress to empower the Government to purchase other of the foreign-owned railways in order to nationalise them. While no such authority had yet been given, it was known that the present Minister of Finance, Dr. Penedo, had under consideration a comprehensive plan for meeting the present economic position in Argentina, which plan included the possible purchase of railway holdings, such purchases being dependent upon the credit that might be required by the British Government for wheat and meat. In closing his address, Sir Follett announced that after the meeting his place would be taken by Mr. J. M. Eddy, C.B.E.

# Some Fallacies Concerning the Petrol Engine

By Professor W. T. DAVID

CERTAIN fallacies concerning the high-speed internal combustion engine, particularly the petrol engine, have gained currency, and these, acting consciously or subconsciously in the minds of designers, have, it is thought, tended to impede progress, splendid though this obviously has been. A few of these are considered in this article.

## I

It is thermodynamically desirable that the chemical energy of the charge in a spark-ignition engine should be wholly released up to the limit imposed by dissociation by the time the peak pressure is reached. It is often assumed that when the indicator diagram shows a sharply defined peak pressure the chemical energy has been fully released, but this is always far from being the case. Proof of this may be obtained in two ways :—

(1) By comparing the actual rise of pressure after explosion with the theoretical rise of pressure calculated upon the basis of accurate specific heats and dissociation data and allowing for heat loss during the explosion. This was done by the writer in 1924[1] in connection with a carefully conducted gas engine test made by Hopkinson on the basis of the best thermal data known at the time, and by fortunate chance the calculations then made agree closely with those made recently by Dr. A. S. Leah, using accurate thermo-chemical data. Although Hopkinson's optically recorded indicator diagram showed a sharply defined peak pressure, the calculations made clear that only about 70 per cent. of the chemical energy of the charge had been released by the time the peak pressure was reached. Dr. F. W. Lanchester's examination[2] of the more recent gas engine tests of Dr. J. S. Clarke shows that some 90 per cent. of the chemical energy of the charge had been released by the time the peak pressure was reached. This is a much higher proportion than is usually obtained, and it is interesting to note that Clarke's engine was fitted with a specially designed hemispherical combustion space. Drs. Withrow and Cornelius[3] have recently concluded tests on a petrol engine running on iso-octane and also on benzene, and they show that only 81 per cent. of the heat of combustion of the charge could be accounted for by the pressure rise after explosion. Their engine ran at a speed of 600 r.p.m. and a generous estimate of the heat lost during explosion would be 3 per cent. of the heat of combustion, so that only about 84 per cent. of the heat of combustion was released.

(2) By comparing the expansion curve of an actual indicator diagram with a theoretically calculated adiabatic expansion curve drawn through a peak pressure of the actual indicator diagram. In spite of heat lost during the expansion stroke in the engine, the actual expansion curve lies well above the theoretical curve in all the cases which have been examined. Indeed, in some cases the actual expansion curve approximates to the isothermal form. Clearly there is a continued evolution of heat during the expansion stroke.

In previous articles[4] it has been shown that the incomplete combustion of the charge at the peak pressure results from imperfect mixing of the unburnt charge and that the after-burning during the expansion stroke results from the more perfect mixing brought about by the very violent, turbulent motion set up as a result of the explosion.

Petrol engines, even aero-engines, of the same compression ratio and of similar general design often show wide differences in fuel consumption per horsepower per hour. This is in large measure due to varying degrees of charge heterogeneity. Not enough attention has been paid to the desirability of securing as perfect a charge homogeneity as possible, and it seems clear that this is one of the main directions in which progress should be made. And this not only from the point of view of fuel economy, but also, as Mr. Ricardo points out in his book on "Engines of High Output," from the point of view of reliability and durability. It will be realised that the more complete the combustion at the peak pressure in any given engine the lower will be the gas temperature at the end of expansion and consequently less heat will be given out to the exhaust valve during the rapid issue of the exhaust gases.

## II

It has been found that in all petrol engines the power increases as the fuel-air mixture supply is increased in strength from the correct to about 20 per cent. rich—sometimes by as much as from 5 to 6 per cent. In the case of ethyl-alcohol the power goes on increasing with even richer mixtures, but the alcohol fuels are exceptional in this respect and are excluded from the following considerations.

In the light of the work of Tizard and Pye it is usually assumed that this considerable increase in power with mixture richness results simply from the chemistry and physics of combustion. But Tizard and Pye made their calculations on the basis of what are now known to be incorrect specific heat data and, furthermore, they did not include dissociations which exercise a powerful influence upon efficiency and power calculations. When these are taken into account the increase in power to be expected is small, and particularly is this so when allowance is made for the unavoidable heat losses which take place during explosion and expansion. That this is so is clearly shown in the full-line curves of Fig. 1 relating to octane-air mixtures supplied to an engine of compression

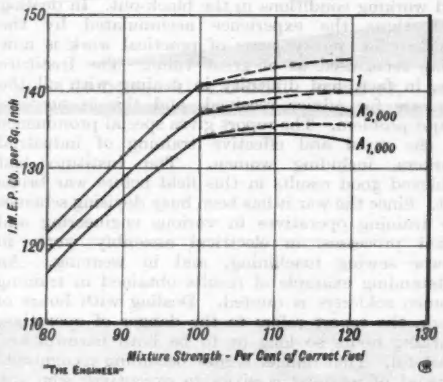



FIG. 1

ratio 5 : 1. In this figure the ideal powers to be expected, assuming a constant volumetric efficiency, are shown in Curve I and those estimated for a compact combustion chambered engine of 4·5in. diameter running first at 1000 r.p.m. and then at 2000 r.p.m. are given by the curves $A_{1000}$ and $A_{2000}$. When the increase in volumetric efficiency with mixture strength commonly found in practice is taken into account the increase in power to be expected is shown by the dotted curves. This increase in power is, however, less than that generally found in engines, and the explanation which has been suggested is in terms of charge heterogeneity.[5] It has been shown that the incomplete combustion at the peak pressure (referred to the oxygen of the air) to be expected after the explosion of a heterogeneous charge decreases as the degree of richness of the mixture increases. Efforts to reduce the degree of mixture richness on which petrol engines usually run are continuously being made, and improvement in charge mixing will assist in these efforts, not only because an increase in power would result owing to more complete combustion at the peak pressure, but also because the engine would tend to run cooler on account of the lower temperatures of the gases just before the exhaust valve opens.

## III

Mr. Ricardo[6] has shown that with the exception of the alcohols the volatile fuels suitable for spark-ignition engines yield approximately the same efficiency when tested in any given engine under conditions in which detonation does not occur. Ethyl-alcohol, due to its high latent heat, yields a slightly higher efficiency. Apart, therefore, from the tendency to detonate the inference from these experiments is that there is little to choose amongst these fuels from the point of view of efficiency. Unfortunately, Ricardo's experiments were made with fuel-air mixtures about 15 per cent. weak, in which there is an excessive amount of incomplete combustion, and such weak mixtures in any given engine show a quite remarkable tendency to yield the same efficiency. For example, although the efficiency yielded by an engine varies widely with the degree of heterogeneity of the charge for most mixture strengths, it is very similar when the mixture strength is in the neighbourhood of 15 per cent. weak. The curves in Fig. 2 show this clearly. The curve A shows the efficiencies obtained by Ricardo in his E.35 engine running at 1500 r.p.m. at a compression ratio of 5 : 1 on mixtures varying in strength between about 15 per cent. weak and the correct mixture when the charge appears to have been mixed more perfectly than is usually the case. Curve C shows the efficiencies obtained when arrangements were made for definite stratification of the charge, and curve B the efficiencies when the charge mixing would appear to be much as normally occurs in engines. It will be noted that while the efficiencies vary widely for most mixture strengths they are very nearly the same when the mixture strength is about 15 per cent. weak.

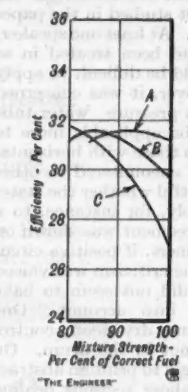



FIG. 2

Ideal efficiency calculations show appreciable differences in the efficiencies to be expected from any given engine when running on various fuels. The extent of these differences may be seen from an examination of the ideal efficiencies shown in Table I, which relate to fuel-air mixtures about 17·5 per cent. rich supplied to an engine of compression ratio 6 : 1. It will be noted that the efficiency to be expected from octene is about 5 per cent. greater than that to be expected from benzene.

TABLE I

| Fuel. | Ideal efficiency. | Authority. |
|---|---|---|
| Octene | 32·7 | Tsien and Hottel* |
| Octane | 32·0 | Tsien and Hottel* and David and Leah† |
| Benzene | 31·0 | David and Leah† |

* *Journal* of Aeronautical Society, March, 1938, page 203.
† "Proc.," I. Mech. E., October, 1940, page 293.

In the case of gaseous fuels the efficiencies to be expected in any given engine differ widely with the nature of the fuel. In Table II are shown the results of calculations of ideal efficiencies for 20 per cent. weak mixtures of methane, hydrogen, and carbon-monoxide and air used in an engine of compression ratio 5 : 1.

TABLE II

| Fuel. | Ideal efficiency. | Experimental efficiency (A. F. Burstall). |
|---|---|---|
| Methane | 37·0 | 33·5 |
| Hydrogen | 36·2 | 32·5 |
| Carbon-monoxide | 32·5 | 29·5 |

It will be seen that the efficiency for the methane mixture is the highest and that for the carbon-monoxide mixture very much the lowest. The efficiency for the hydrogen mixture approaches that for the methane mixture. Professor A. F. Burstall's experiments made in an E.35 Ricardo engine running at 1500 r.p.m. check up very satisfactorily with the ideal calculations. It should be added that with 20 per cent. weak gaseous mixture there is not the excessive incomplete combustion found in the 15 per cent. weak volatile fuel tests, and consequently experiment and theory may be satisfactorily compared.

## IV

The heat to the cooling water expressed as a percentage of the heat of combustion of the fuel does not differ very much in many high-speed engines from that in low-speed engines, and this, unfortunately, has led to the view that the heat lost by the hot gases during explosion and expansion expressed as a percentage of the heat of combustion does not vary greatly with engine speed. Thus Dr. D. R. Pye[7] assumes that in a compact combustion chambered engine of 4·5in. diameter and compression ratio 5 : 1, running without detonation at 1500 r.p.m., the heat loss amounts

[1] "Proc.," I. Mech. E., 1924, page 741.
[2] "Proc.," I. Mech. E., June, 1939, page 304.
[3] *J.*, S.A.E., Vol. 47, No. I, July, 1940, page 60.
[4] THE ENGINEER, April 22nd and 29th, 1938.
[5] THE ENGINEER, April 22nd, 1938, and David and Leah, "Proc.," I. Mech. E., October, 1940, page 303.
[6] "The High-speed Internal Combustion Engine," Blackie, 1931, page 126.
[7] "The Internal Combustion Engine," Clarendon Press, 1927, page 275.

to 5 per cent. of the heat of combustion of the fuel burnt during explosion and 10 per cent. during expansion. On the basis of these estimates he finds the distribution of the 28·5 per cent. of the heat of combustion measured in the cooling water to be as follows :—

| | Per cent. heat of combustion. |
|---|---|
| From cylinder head ... ... ... ... ... | 11·5 |
| From cylinder barrel ... ... ... ... ... | 13·0 |
| From exhaust valve and passages beyond | 4·0 |
| | 28·5 |

This heat loss distribution is quite incorrect, and indeed probably no high-speed engine in which the cooling arrangements were designed on the basis of this distribution would run for more than an hour or so without breaking down. There are many ways of showing the inaccuracy of Pye's suggested distribution—probably the simplest being that of comparing his cylinder head and cylinder barrel percentages with those measured in engines running under similar conditions in which the head and the barrel were separately cooled. Thus Ricardo found in a sleeve valve engine of 4·5in. diameter and compression ratio 4·3 : 1 running at 1500 r.p.m. a heat loss to the cooling water in the separately cooled head amounting to 4·8 per cent. of the heat of combustion of the fuel burnt. This is far less than Pye's suggested figure of 11·5 per cent. Again, Professor C. Fayette Taylor,[8] in a "Liberty 12" poppet valve engine of 5in. diameter and compression ratio 4·58 : 1, running at 1600 r.p.m., found the heat loss to the cooling water of the separately cooled barrel to be 5 per cent. of the heat of combustion, which is also far less than Pye's figure of 13 per cent. Even the 4·8 per cent. to the head is a little high for a compact combustion chambered engine, for the cylinder head in Ricardo's engine had the form of a deep cone, so that its surface area was large ; and the 5 per cent. to the cylinder barrel is also probably a little high, for the heat generated by piston friction in Taylor's engine appears to be unusually large.

It has been suggested by the writer that the heat loss distribution in the engine considered by Pye is as follows[9] :—

| | Per cent. heat of combustion. |
|---|---|
| From cylinder head ... ... ... ... ... | 4·5 |
| From cylinder barrel ... ... ... ... ... | 4·5 |
| From exhaust valve and passages beyond | 19·5 |
| | 28·5 |

It will be noticed that the proportion of the total heat to the cooling water which enters *viâ* the "exhaust valve and passages beyond" (which should include a small portion of the cylinder head surrounding the exhaust valve seating, because it is subject to the scrubbing action of the issuing gases during exhaust) is very large, namely, five-sevenths, as compared with Pye's suggested one-seventh. This explains many things in regard to the functioning of the high-speed engine which were difficult to account for. These will be considered in another article ; meanwhile it may be observed that the necessity for the generous cooling arrangements in the neighbourhood of the exhaust valve in high-speed engines which have been evolved as a result of practical experience becomes understandable.

# Statistical Methods in Engineering Practice

## No. IV—QUALITY STANDARDS IN PURCHASING SPECIFICATIONS

By H. RISSIK

(*Continued from page 373, December 13th*)

WE have seen how statistical technique, as exemplified in Shewhart's quality control chart, provides the manufacturer with a powerful analytical tool which, if used with discretion, enables him to detect causes of trouble in his production processes.[1] An even more important aspect of this same statistical technique is its use by the consumer in establishing appropriate standards of quality in his purchasing specifications. In fact, the rapid and widespread development in the national, and even international, standardisation of industrial products during the present century (see Fig. 9) has led to a growing

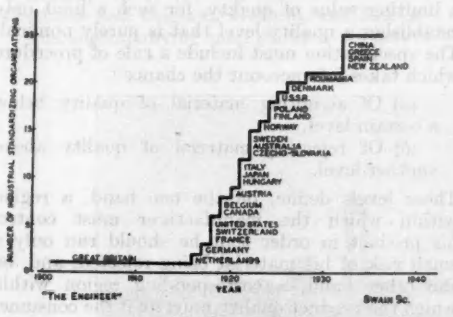



FIG. 9

realisation among standardising organisations generally of the value that attaches to a statistical outlook on the drafting of standard specifications. For the main task of these organisations is to specify universally acceptable standards of quality.

Naturally such specifications, whose basic aim is to protect the consumer, have their repercussions in the sphere of production. Faced with a specification embodying a definite quality standard to which his product must conform, the manufacturer at once finds himself involved in a twofold problem. He now has to devise ways and means of minimising, on the one hand, the proportion of his output rejected by the specification, and, on the other hand, the cost of inspection necessary to give him adequate assurance that the quality of his product meets the specified standard. The former problem is essentially that of quality control in manufacture which we have already discussed. The latter is a problem of economics—the economics of sampling inspection—to which we shall turn later. For the moment our concern is with the fundamental question of defining a quality standard.

### DISCRIMINATION BETWEEN SATISFACTORY AND UNSATISFACTORY QUALITY

The first step in specifying any standard of quality is that of establishing a quality criterion. From the engineering standpoint this seems to be a perfectly simple and straightforward matter. For example, a user of die castings is, as a rule, interested mainly in their tensile strength, so that naturally he will choose this physical property as the basis for any criterion of quality. Suppose that his designs call for a grade of die-casting alloy having a tensile strength of not less than 45,000 lb. per square inch. He will then decide to incorporate this engineering requirement in his purchasing specification. It is precisely here that the difficulties commence. Because, as we have already seen, tensile strength is not a physical constant, like the acceleration due to gravity or the charge on an electron, but a statistically controlled variable whose numerical interpretation takes the form of a frequency distribution—a relation between specific values and the relative frequencies with which they occur.[2] On what principle, then, is our purchaser of die castings to employ a minimum value of tensile strength as a quality criterion enabling him to discriminate between satisfactory and unsatisfactory material ?

What, in fact, is the intent of a requirement that specifies merely a minimum limit for tensile strength ? Does this mean that, in any batch of castings, no individual piece or no possible test specimen[3] shall have an actual value of tensile strength that fails to come up to the specified minimum by even the smallest of margins ? If it does, then compliance with such a requirement clearly cannot be enforced. Or does it mean that a batch presumably containing a few castings whose tensile strength is below the minimum limit will not become suspect and on that account be rejected as non-conforming by the purchaser ; in other words, that a small percentage of any batch submitted by a supplier may be permitted to fall below the limit specified ? If so, what is the allowable percentage to be ? Furthermore, with what degree of assurance should a batch containing a percentage of non-conforming pieces larger than this allowable value be prevented from passing as acceptable ? Questions such as these inevitably arise in the course of attempting to establish criteria of quality which will discriminate between satisfactory and unsatisfactory material products.

### THE CHOICE OF AN APPROPRIATE QUALITY CRITERION

In view of the statistical nature of material quality characteristics, the only logical means of specifying quality standards is by way of establishing discriminatory criteria based on the frequency distribution of the quality characteristic concerned. To simplify the problem the assumption will be made that this frequency distribution is normal. (The assumption is justified in so far as the product in question is statistically controlled during manufacture, which in practice it will be under up-to-date conditions of mass production and close co-operation between producer and consumer.) In the case of engineering specifications incorporating, as they usually do, minimum or maximum limits, the element in a frequency distribution which is of most interest is the so-called "fraction defective" or "fraction non-conforming"—that is, the proportion $p$ of all possible values of the quality characteristic which fall below the minimum or above the maximum limit L specified. Referring to equation (4 *b*) a little consideration will show that this proportion is defined by the relation

$$p = \int_{L}^{\infty} \phi(t) \, . \, dt \quad . \quad . \quad . \quad (10)$$

where, in this case, the variable $t$ has the value

$$t = \frac{L - \bar{x}}{\sigma} \quad . \quad . \quad . \quad . \quad . \quad (11)$$

Here $\bar{x}$ is the average value of the quality characteristic $x$ and $\sigma$ is its standard deviation, as defined by equations (2) and (3) respectively. The above equations lead automatically to the choice of the average $\bar{x}$ as a basis for discriminating between satisfactory and unsatisfactory quality.

A factor of great practical importance favouring such a choice is that the sampling distribution of averages is normal even when the parent distribution is itself far from normal. That is to say, if a manufactured product is not statistically controlled, so that equation (10) is no longer generally applicable (except, perhaps, as an approximation), then if the average quality of a sample selected at random be taken as the variable, in place of the quality of an individual piece of product, equation (10) defines the proportion of *samples* whose average quality falls outside the specified limit L. From the purchaser's point of view this approach to the problem of specification is, too, the only practical one. For it is but seldom that he is in a position to examine every item of product. In practice he is bound to accept as evidence of product quality samples drawn at random from the batches of product received from his several suppliers. A further point in favour of basing a quality criterion on the average $\bar{x}$ is that for purely domestic reasons, and quite apart from any desire to facilitate compliance with a specification, producers will endeavour to attain a state of statistical control in their manufacturing processes. As a result, when a number of producers are all supplying material to a common specification, the purchaser may legitimately expect to encounter differences in quality level rather than in variability about a given level—differences in the average $\bar{x}$ rather than in the standard deviation $\sigma$, in other words—differentiating his several suppliers. For their manufacturing processes, being similar on the side of variability (*e.g.*, use of machines of the same general type), will give rise to quality distributions having very much the same standard deviation ; whereas local peculiarities (*e.g.*, jig fixtures, methods of machine loading, &c.) will tend to produce distribution averages that are characteristic of the individual manufacturers.

It must not be thought, however, that the average of a frequency distribution necessarily provides an infallible means of discriminating between satisfactory and unsatisfactory quality. If the purchaser has grounds for suspecting that the product qualities of his several suppliers exhibit

[8] *Journal* of Aeronautical Sciences, June, 1936, page 282.

[9] THE ENGINEER, April 29th, 1938.

differences in variability, without appreciable change in the quality level, then clearly a criterion based on the use of average quality alone will be inefficient in detecting unsatisfactory batches of material. In that case, a quality criterion which makes use of the standard deviation in conjunction with the average, or of the coefficient of variation of the frequency distribution, will provide sharper discrimination between satisfactory and unsatisfactory quality.[4] The characteristic of a frequency distribution which is perhaps the most widely used of all, both for establishing appropriate quality standards and for controlling quality in manufacture, is the fraction defective. This particular statistic is, of course, the only possible measure of quality available where the quality characteristic is an attribute, *e.g.*, colour, finish, or any other feature of like kind enabling a clear distinction to be made between a defective and a non-defective item of product. In the case where the quality characteristic is a variable, whose values can be defined with reference to a continuous scale of measurement, some definite value of the variable may be chosen to form the line of demarcation between defective and non-defective product. Experience indicates, however, that the fraction defective—here simply the ratio of the number of defective items found in a batch to the total number of items in the batch—is probably the least efficient measure of quality in such a case. For example, Shewhart has shown that, as far as quality control in manufacture is concerned, the average is a much more sensitive detector of assignable causes of variation than is the fraction defective.[5] In sampling inspection also, it has been found that inspection routines based on the average are inherently more economic than are those making use of the fraction defective.[6] In fact, there is to-day ample evidence to justify a choice of the average in preference to the fraction defective as a basis for establishing industrial standards of quality.

### The Specification of Standard Quality

To illustrate the use of a quality criterion based on the average of a frequency distribution in establishing an appropriate standard of product quality, let us consider further the case of a user of die castings who seeks some measure of assurance that his purchased material will have a minimum tensile strength of 45,000 lb. per square inch. Suppose that he specifies the following acceptance (or rejection) criterion for his batches of purchased material :—

> Accept the batch if the average tensile strength, $x_n$, for a sample of $n$ items selected at random from the batch is equal to or greater than 45,000 lb. per square inch. Reject the batch if the sample average falls below this minimum strength limit.

The protection to the consumer afforded by such a quality criterion is clearly not absolute. There is no guarantee that a batch accepted on this basis will contain no items whose tensile strength is below the specified minimum limit, not even when all the items in the sample give values of tensile strength which exceed the minimum. Absolute protection is only to be obtained by 100 per cent. inspection of the batch. But an acceptance criterion resting on this basis is seldom an economic possibility and is physically impossible of attainment in the case of, say, breaking strength where the nature of the inspection test is destructive. Even for material testing that is non-destructive, there may exist no natural discrete pieces which can be separately tested for conformity with a specification of quality (*e.g.*, shipments of wire, or of cement or similar materials supplied in bulk). In general, then, there is no alternative to testing a relatively small sample of the whole, and thus to a corresponding fall in consumer protection from that absolute standard which exists only as an ideal.

To investigate the degree of consumer protection afforded by the above discriminatory criterion, we must consider the expected fluctuations of averages for samples of size $n$, when sampling from a product whose quality has an unknown frequency distribution of average $\bar{x}$ and standard deviation $\sigma$. For any given values of $\bar{x}$ and $\sigma$ the averages of some definite proportion $p$ of all possible samples drawn at random from the batch will be expected to lie above the limit L=45,000. This proportion is, in fact, the chance or probability that a product having a quality defined by the given values of $\bar{x}$ and $\sigma$ will be accepted. It is thus a measure of the consumer's risk of accepting batches of material containing items whose quality falls below the standard aimed at. At the same time, it is a measure of the producer's risk of having his batches of material rejected by the purchaser. The proportion $p$ of samples whose averages $x_n$ exceed the limiting value L is defined by equation (10), where in this case the variable $t$ takes the value

$$t=\frac{L-\bar{x}_n}{\sigma_n} \quad . \quad . \quad . \quad . \quad . \quad (12)$$

Here $\bar{x}_n$ is the expected value of the sample average $x_n$—that is, the grand average of all possible values of $x_n$. Irrespective of the nature of the frequency distribution of $x$, the expected value of $x_n$ can be shown to coincide with the average of the unknown distribution, so that $\bar{x}_n=\bar{x}$. Similarly, the standard deviation $\sigma_n$ of the sample average $x_n$ can be shown to have the value

$$\sigma_n=\frac{\sigma}{\sqrt{n}}\cdot\sqrt{\left(\frac{N-n}{N-1}\right)} \quad . \quad . \quad . \quad (13)$$

where N is the number of items in the batch from which the sample $n$ is drawn. If the sample is small (as is generally the case), so that it comprises but a small percentage—say, not more than 10 per cent.—of the items in the batch, $n$ may be neglected in comparison with N without appreciable error. Hence we may put $\sigma_n=\sigma/\sqrt{n}$, and equation (12) then becomes

$$\bar{x}=L-\frac{t\sigma}{\sqrt{n}} \quad . \quad . \quad . \quad . \quad (14)$$

For a given sample size $n$ the value of $t$, determining the proportion $p$ of samples whose averages exceed L, will thus depend on the average quality $\bar{x}$ of the product represented by the batch. The relation between $p$ and $\bar{x}$ for samples of ten ($n=10$) is shown diagrammatically in Fig. 10, where L=45,000. The upper diagrams show

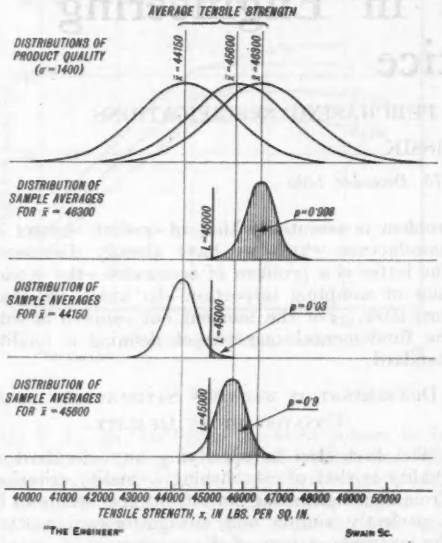



FIG. 10

three distributions of product quality having different levels, but the same standard deviation ($\sigma=1400$), and represent the distribution of tensile strength $x$ in batches of material obtained from three different suppliers whose production processes are already in a state of statistical control. The three lower diagrams show the corresponding distributions of the sample averages $x_n$. In the first case, where the producer maintains a high quality level represented by $\bar{x}=46,300$, all but 2 samples out of 1000 will be expected to meet the specified acceptance criterion. In the second case, where the producer is only able to maintain a quality level given by $\bar{x}=44,150$, only 3 out of 100 samples will be expected to conform to the purchaser's requirements. In the case of batches supplied by the third producer, whose quality level is $\bar{x}=45,600$, the probability is that 90 per cent. will be accepted by the purchaser.

Fig. 11 shows the relation between the acceptance probability $p$ and the producer's quality level $\bar{x}$ for samples of 5, 10, 25, and 50. It will be seen that if the producer wishes to reduce to less than 1 per cent. the risk of having his material rejected, then he must maintain an average tensile strength of 46,450 lb., 46,050 lb., 45,650 lb., or 45,450 lb. per square inch, depending on the chosen sample size. For quality levels below these values his material would often be accepted ; but as his average quality fell, so the chance of acceptance would decrease. If the consumer is satisfied to risk accepting batches proved to be below standard quality in 10 per cent. of the cases, then the corresponding levels to be maintained by his suppliers need be only 44,200 lb., 44,420 lb., 44,640 lb., or 44,750 lb. per square inch, depending on the sample size fixed upon in the purchasing specification. For a given size of sample, therefore, there are two significant levels of quality whose separation is, in a general sense, a measure of the efficacy of the quality criterion in discriminating between satisfactory and unsatisfactory batches of product. To take the case of $n=5$, for example, the upper quality level corresponding to a 1 per cent. producer's risk (of rejection) is $\bar{x}=46,450$, while the lower level corresponding to a 10 per cent. consumer's risk (of acceptance) is $\bar{x}=44,200$. The belt of uncertainty between these two levels—the so-called producer's and consumer's "safety levels"—is indicated in Fig. 11 by the horizontal distance

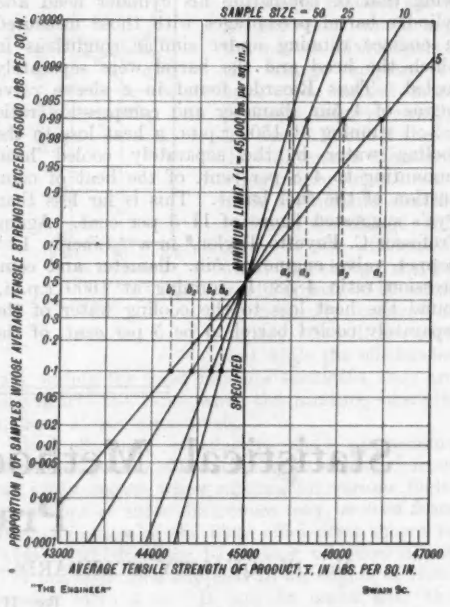

SAMPLE SIZE = 50 25 10
5
MINIMUM LIMIT (L = 45000 lbs. per sq. in.)
SPECIFIED
PROPORTION p OF SAMPLES WHOSE AVERAGE TENSILE STRENGTH EXCEEDS 45000 LBS. PER SQ. IN.
0·9999 0·999 0·995 0·99 0·98 0·95 0·9 0·8 0·7 0·6 0·5 0·4 0·3 0·2 0·1 0·05 0·02 0·01 0·005 0·001 0·0001
43000 44000 45000 46000 47000
AVERAGE TENSILE STRENGTH OF PRODUCT, x̄, IN LBS. PER SQ. IN.
"THE ENGINEER"
SWAIN Sc.

FIG. 11

between the lines $a_1$ and $b_1$. It will be observed that this belt can be narrowed by increasing the sample size, as shown by the distances $a_2$ $b_2$, $a_3$ $b_3$, and $a_4$ $b_4$ for samples of 10, 25, and 50 respectively. Hence, when using average quality in establishing a criterion that will enable one to discriminate between the satisfactory and the unsatisfactory, the degree of discrimination obtainable for given producer's and consumer's risks is determined not only by the specified acceptance limit, but also by the size of the sample selected at random as being representative of the product as a whole.

In the specification of quality standards, therefore, it is not sufficient merely to specify a limiting value of quality, for such a limit only establishes a quality level that is purely nominal. The specification must include a rule of procedure which takes into account the chance :

> (*a*) Of accepting material of quality below a certain level.
>
> (*b*) Of rejecting material of quality above another level.

These levels define, on the one hand, a region within which the manufacturer must control his product in order that he should run only a small risk of his material being rejected, and, on the other hand, a corresponding region within which the product quality must lie if the consumer is to reduce to a small risk the chance of accepting material which is below the standard represented by the nominal quality level. The efficiency of the specification may then be taken as proportional to the narrowness of the belt in between these two levels.

#### References

[1] See Parts II and III of the present article, entitled "Quality Control in Production Engineering," which appeared in THE ENGINEER, December 6th and 13th, 1940.

[2] See Part I of the present article, entitled "Fundamental Aspects of Statistical Technique," which appeared in THE ENGINEER, November 29th, 1940.

[3] See *Light Metals*, June, 1939, for a method of measuring tensile strength in small specimens taken from actual castings.

[4] *Cf.* E. S. Pearson, "A Survey of the Uses of Statistical Method in the Control and Standardisation of the Quality of Manufactured Products," *Journ., Roy. Stat. Soc.*, Vol. XCVI, Part I, 1933, page 21.

[5] *Vide* W. A. Shewhart, "Economic Control of Quality of Manufactured Product," pages 412–14 (McMillan and Co., London, 1931).

[6] *Cf.* H. F. Dodge, "Statistical Control in Sampling Inspection," *American Machinist*, October 26th and November 9th 1932.

*(To be continued)*

# Air Force Targets in Germany

No. XV

(*Continued from page 361. December 6th*)

### COLOGNE AND ITS ENVIRONS

AFTER Hamm and Hamburg, there are few districts in northern and western Germany which have suffered more frequent air attacks than has the City of Cologne and its immediate surroundings, which have been visited close upon sixty times. From the first days of the war, attacks have been directed by the aircraft of the Bomber Command against docks and harbours, railway centres and shunting yards, bridges and the industries of the district, which include heavy engineering, cable making, chemical works, and oil production and refining. Cologne is the third largest city in Germany and has a population of something over 700,000. It lies in a semicircle on the left bank of the Rhine, and by railway it is a distance of about 44 miles north-east of Aachen, some 24 miles south-east from Düsseldorf, and close to 57 miles north-west from Coblenz. In addition to its being an important Rhine port, it is a busy rail centre for both goods and passenger traffic, while the convergence of many road systems at this point, including several of the new motor roads, makes it a natural Rhine crossing for all traffic between Germany and Belgium, Holland, and France.

HOHENZOLLERN BRIDGE AT COLOGNE

The accompanying map shows a portion of the River Rhine at Cologne, and some of the bridges which connect the city with the eastern suburbs on the right bank of the Rhine. These suburbs form the main centres of industry, and include Köln-Mülheim, Deutz, and Kalk, famous for the cable industry of the Felten and Guilleaume Carlswerk A.G., the Humboldt and Van der Zypen and Charlier mining machinery and compressor works, and Klöckner-Humboldt-Deutz A.G., the home of the German oil and gas engine industry. On the western bank of the river the suburbs to the south and west of the city include those of Bayenthal, Sülz Lindenthal, Ehrenfeld, Bickendorf, Nippes, Riehl, Merheim, and Niehl. The docks include those to the south of the city, the harbour station and Customs harbour, and the Rhenania and Hansa wharves. On the opposite side of the Rhine, at Deutz, are the harbour entrance, the industrial harbour, and a petroleum wharf. Each of these docks has its own railway system, with branches to the principal industrial works, which are thus provided with their own river connection. Above the Mülheim suspension bridge, on the Cologne side of the river, are the important docks at the Niehler Harbour, which was constructed about 1926. It has four basins and a long entrance dock. These docks are indicated in the accompanying map, which also shows some of the railway connections to the docks.

### RECENT AIR ATTACKS

In all, some sixty different attacks have been made on targets in and around Cologne, but outstanding among them in intensity are those which took place during the nights of Tuesday and Wednesday, November 26th and 27th. The first raid was made in the early hours of the Tuesday evening, and was followed by another attack in the early part of Wednesday, when armament works, electric power stations, goods yards, passenger stations, and the dock installations on both banks of the Rhine were targets for our bombers. Fires were started near the Hohenzollern bridge, and warehouses, over thirty in number, were attacked, as well as covered sheds near the docks on both banks of the Rhine. Particularly large fires were observed in one of the large works engaged in armament production. The attack on Wednesday evening was directed against almost the same targets. It lasted from about ten o'clock in the evening until midnight, and was continued the following morning shortly before five o'clock, when the Humboldt factories in the Kalk area were heavily raided. A force of heavy bombers concentrated its attack against the network of railways and shunting yards, the positions of which are indicated in the sketch map we reproduce herewith. In addition to these yards, the passenger stations on both sides of the great Hohenzollern bridge, the Köln-Hauptbahnhof, and the station at Köln-Deutz were also attacked. According to the Air Ministry bulletin, there was good visibility, and soon after the first bomb had fallen large fires, three in number, were seen to break out in the region of the western approach to the Hohenzollern bridge. Later, a large fire was observed in one of the goods yards, while east of the bridge other fires were started, one of which was a mile long and very broad.

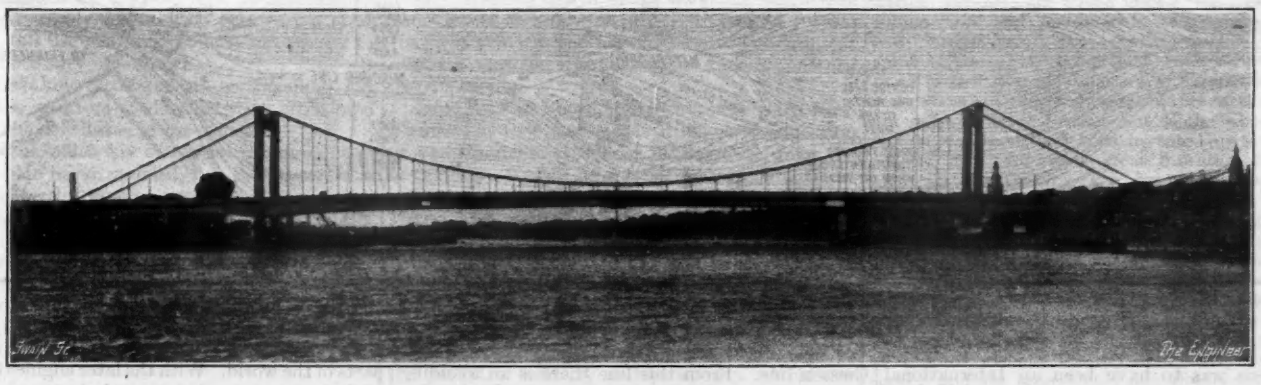
From the reports made after the raids, it is quite certain that our bombing attacks have hindered the flow of essential traffic at this important railway centre. Some idea of the amount of traffic in this area, even in normal times, can be obtained from Reichbahn figures, which state that the daily traffic across the Hohenzollern bridge alone amounts to approximately 306 passenger trains and 45 freight trains, beside many thousands of pedestrians and tramway passengers. To add to the traffic dislocation, other shunting and marshalling yards in different parts of the city were also attacked. These yards are indicated on the sketch map already referred to. The Köln-Gereon yard, to the north-west of the city, was attacked by a small force of heavy bombers, which remained over the target for nearly four hours. During this time numerous incendiary and high-explosive bombs were dropped, which caused many fires and gave rise to subsequent explosions, one of which was very large, it is reported, and lasted fully thirty seconds, an exceptionally long time for an explosion.

In the Eifeltor yard, to the south of the city, many fires were started and formidable explosions occurred. Bursts were also observed in the Köln-Kalk yard between Kalk and Mülheim, and also in the Köln-Nippes yard to the north of the city, on the west side of the river. The various docks and harbours were also attacked on both sides of the Rhine, and fires ensued; one of the principal Cologne power stations was also heavily bombed. Many pilots reported direct hits in the target areas, and considerable damage appears to have been caused.

### RHINE BRIDGES AT COLOGNE

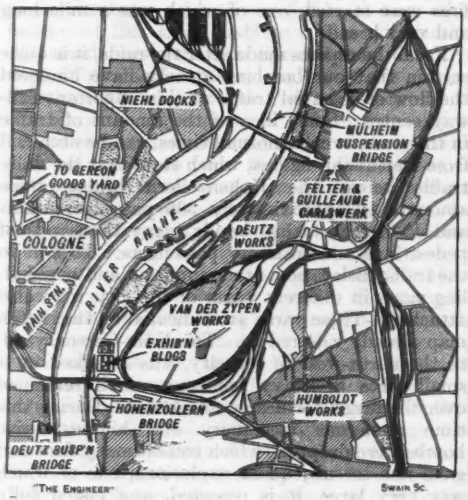
Before dealing with the railway network and some of the industries for which the Cologne area is noted, some account of the Rhine bridges and their history may be of interest to our readers.

The first bridge constructed between Cologne and Deutz was of the pontoon type and was built in 1674. It lasted until 1832, when it was replaced by another pontoon bridge. These bridges were built for road traffic and pedestrian use, and the wooden floors were replaced from time to time. The length of these bridges was about 1400ft. In 1859 these early bridges were followed by the first railway bridge, which was designed by Herr Hartwich, who was a well-known constructor of bridges about that period. The bridge was built of wrought iron, comprised separate spans, and carried road and railway traffic. It took about four years to finish. The provision of a clearance of about 47ft. between the water level of the river and underside of the bridge proved to be a considerable help to the development of river-borne traffic.



SUSPENSION BRIDGE BETWEEN COLOGNE AND MULHEIM

This bridge was in turn followed by the Hohenzollern bridge, a view of which we reproduce in the accompanying engraving. It was constructed between the years 1907 and 1910. Its total length is nearly 1345ft. The centre span has a length of 551ft. and the two side spans 390ft. and 404ft. respectively. It is composed of three parts, two railway bridges each with two tracks, a road bridge with a double tramway track, and a footpath on each side. A feature of this bridge, which will be noted from our illustration, is its architectural treatment. The architects responsible for its design were Beermann and H. F. Schweckten, while G. Riegelman was entrusted with the ornamental work. On the




COLOGNE AND ENVIRONS

Cologne side are equestrian statues of Frederick III and Wilhelm II, while on the Deutz side are statues of Frederick-Wilhelm IV and Wilhelm I, which were taken from the old bridge.

As will be seen in the engraving, there is to the left of the bridge, on the Deutz side, the Cologne Exhibition Grounds, which were built in 1922 from designs prepared by Verbeck and Pieper. They include a large Hall of Honour and other buildings in which many Cologne Fairs and Exhibitions have been held. One of these was the Press and Printing Exhibition of 1929. Had there been no war, it was intended to hold a special exhibition this year in Cologne dealing with road building and road transport, in connection with which there was to have been an International Congress. At the outbreak of the war, far-reaching preparations had already been made in connection with the proposal, which was sponsored by an influential committee led by Dr. Julius Dorpmüller, the German Minister of Transport, and Dr. Todt, the Chief Inspector of Road Construction.

A little further upstream from the Hohenzollern bridge is a small suspension bridge. It replaced a former pontoon bridge, was built between 1913 and 1916, to designs prepared by K. Moritz, and has a central span of about 605ft. To the south of the Hohenzollern bridge is another important railway bridge, the Südbrücke, which is mainly reserved for goods traffic. It was designed by the same architects who were entrusted with the Hohenzollern bridge, and besides the railway track has a footway. The centre span of this bridge is 541ft. long.

The newest bridge in the Cologne area is that between Cologne and Mülheim, which was built between 1927 and 1929, and replaces a former pontoon bridge. It is shown in one of our engravings. It has a central span of 315 m., and there are two side spans, each of 91 m., while the width is 30·55 m. The bridge includes a wide carriageway and two footpaths. Its construction was carried out by the firm of Harkort, of Duisburg, and the principal contractors engaged in its construction were the Maschinenfabrik Augsburg-Nürnberg, of Gustavsburg, the Vereinigte Stahlwerk A.G., of Duisburg, and Felten and Guilleaume Carlswerk A.G., of Köln-Mülheim.

## RAILWAYS IN THE COLOGNE AREA

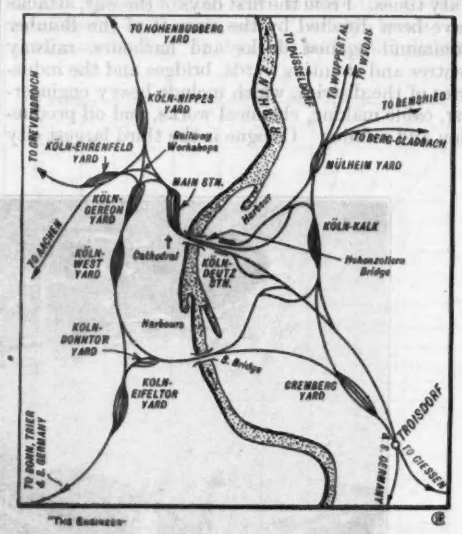
Cologne is one of the biggest railway centres in Western Germany and has an extensive network of lines on each side of the Rhine. The main centre of the city, with the famous cathedral, the beautiful Gurzenich hall (corresponding to London's Guildhall), and the central railway station or Hauptbahnhof, are all situated on the western or left bank of the river.

Nearing Cologne by rail from the west, *viâ* Brussels and Aachen, probably the most usual approach for the British visitor, the line from Grevenbroich comes in from the north and passes Köln-Ehrenfeld freight station, which is situated on the north of the main line. After passing through the passenger station of that name, a line diverges northwards to the large marshalling yard of Köln-Nippes, but passenger trains turn south-eastwards, leaving Köln-Gereon with its goods yards, wagon repair shops, and marshalling yards, just to the south before entering the main passenger station. This station is close to the cathedral, and forms a large through station with about ten platform faces. It is built about 20ft. above the street level, and below it are spacious restaurants and offices. Immediately after leaving the Hauptbahnhof, the lines turn due east and converge into the four tracks, which cross the Hohenzollern rail and road bridge, leading across the Rhine to Köln-Deutz, after which passenger station the lines bifurcate north-eastwards, *viâ* Köln-Mülheim, to Düsseldorf, Wuppertal, and Berg-Gladbach, and south-east to Frankfurt and Giessen.

The large marshalling yard at Köln-Kalk forms the third side of this triangle, while the enormous Gremberg marshalling yard serves the Frankfurt-Giessen line. From this line there is an avoiding line, which crosses the Rhine by the Südbrücke, and after passing Köln-Bonntor freight station, links up with the freight lines running southward from Köln-Gereon at another huge marshalling yard known as Köln-Eifeltor. This yard serves the main line leading to Bonn and Trier, while Coblenz and Mainz can be reached this way if the left bank of the river is followed. This very complex lay-out, designed so obviously for military purposes as a primary object, will be visualised clearly by referring to the accompanying sketch map. The marshalling yards referred to differ naturally in size and arrangement, but some idea of the lay-out for such a yard will be seen from the plan of the yard at Hohenbudberg, which, it may be noted, lies immediately north of the area indicated on our sketch map. The large size of these yards and their complex lay-out explain the necessity for the repeated raids to which this railway network has been subjected, in common with the rail centres at Hamm, Osnabruck, and Soest.

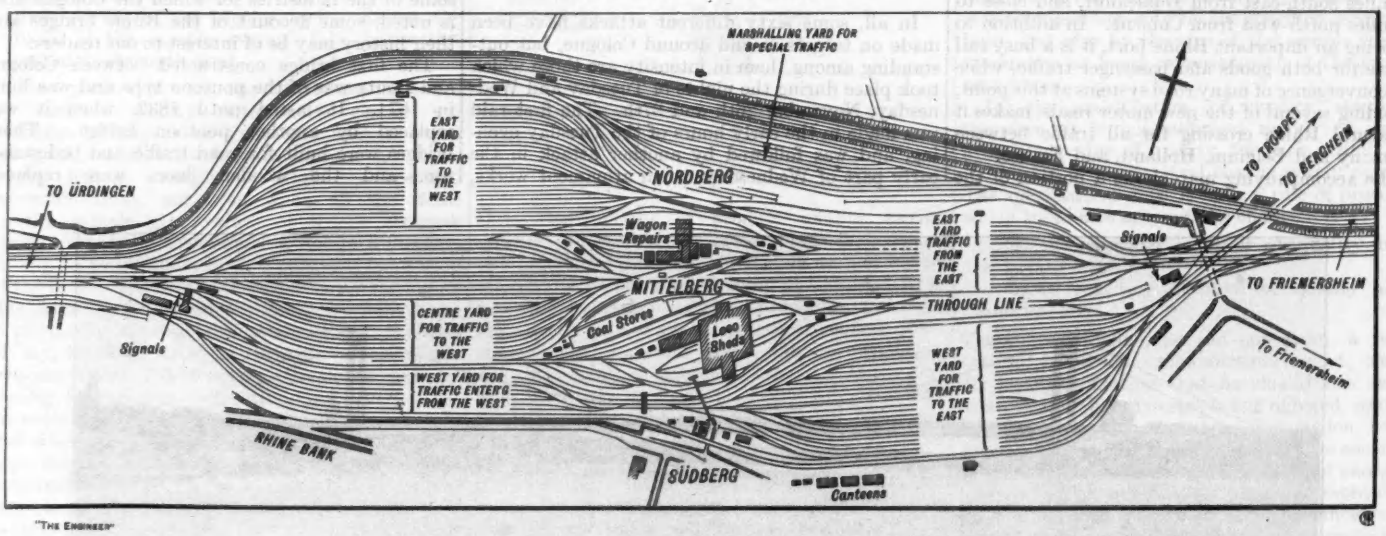
## INDUSTRIAL ACTIVITIES

Earlier in our article we mentioned that the industrial activities of Cologne are mainly situated in the Deutz-Kalk-Mülheim area, on the right bank of the river. The most important undertaking is undoubtedly that of the Klöckner-Humboldt-Deutz A.G., which includes in its scope




RAILWAY CONNECTIONS AROUND COLOGNE

the businesses of the Humboldt mining machinery and heavy engineering works, and the old-established gas and oil engine establishment of the Motorenfabrik-Deutz A.G. These works were founded in 1884 by Nikolus August Otto and Eugen Langen, and were the birthplace of the Otto gas engine, the development of which was entrusted in this country to Crossley Brothers, of Openshaw, Manchester. Starting with the atmospheric engine which was first shown at the Paris Exhibition of 1867, there followed the Otto gas engine, which was seen at the Paris Exhibition of 1878, and marked a new development in internal combustion engine practice, which was followed in all parts of the world. With the later engines the range of fuels was extended to include town's gas and coke oven gas, which was helped by the planning of a gas grid. There then followed engines to utilise light and heavy fuel oils, and the designs of gas and oil engines were extended widely to include horizontal and vertical types, both for industrial transport, and marine purposes. The introduction of the well-known Deutz V M type vertical oil engine for marine use marked an important step forward. From small beginnings, the works were expanded and series manufacture was introduced at an early stage. Shortly before the war the Deutz firm was turning out over 1,500,000 H.P. of engines per year, an output which embraced gas and oil engines with powers from 5 B.H.P. up to 1500




MARSHALLING YARD AT HOHENBUDBERG, NEAR COLOGNE

B.H.P. This firm alone produced about 60 per cent. of the engines which were exported from Germany. Particular success was obtained with engines specially designed for coasting vessels, and in 1939 the majority of vessels of this type, especially those built in Germany and Holland, were equipped with Deutz oil engines.

In the administration building there has been assembled a valuable works museum, in which are to be seen over fifty-four engines, illustrating the development of the internal combustion engine from Otto's first experimental engine to the present time. Alongside thirty-eight engines of Deutz design and manufacture there are some sixteen of other makes which complete the collection. Particularly interesting is the series of exhibits illustrating the progress made in ignition apparatus, which includes the early hot-tube designs and the introduction and development of electric ignition. Other sections deal with the progress of carburation, and the improvements made in engine lubrication. In 1928 the number of workers in the Deutz oil engine factory was close upon 3000, and that number has greatly increased in recent years, with the putting into practice of the Four-year Plan and the increase in armament work, including aircraft and submarine engines.

## Obituary

### ARTHUR DANSIE

THE death of Arthur Dansie, who for nearly forty years had faithfully served on the staff of the Institution of Naval Architects, removes a figure familiar to more than one generation of naval architects. His attendance at the annual meetings of the Institution was as regular as the seasons. Always unruffled and immaculately dressed, he gave of his best to make things easy and pleasant for members and their guests. The smooth running of the meetings and dinners and other entertainments was largely due to his careful preparations and to his tact in meeting the demands made upon him at such times.

Educated privately, he had entered the clerical department of a large business house at an early age, and it was from there that he transferred to the office of the Institution under the late Sir George Holmes.

Dansie's methodical habits and practical common sense soon made him invaluable on the small—the very small—staff which then managed, under the Council, the Institution's affairs. While for most of the year the office work was comparatively light, there came seasons when the approach of a large meeting made heavy calls on the secretariat. In those early days they had none of the modern aids to rapid office work—typewriter, filing and indexing appliances, the addressograph, and other labour-saving devices—and we often wonder now how work for so many could be carried out by so few.

By nature conservative, in the sense of being satisfied with things as they are, Arthur Dansie nevertheless readily fell in with progressive ideas and made full use of improvements introduced to reduce unnecessary office work.

His painstaking accuracy in bookkeeping left little for the auditors to do, and they often paid tribute to the excellence of his work.

Outside the office his tastes lay in music and the stage. He never married, but to a sister with whom he shared a home he was deeply attached, and her death left a gap in his life which never fully closed.

He retired only a few years ago to the regret of a wide circle of friends, and his share in building up the prosperity of the Institution to which he gave a lifetime of loyal service will long be remembered. R. W. D.

### PROFESSOR H. J. SPOONER

ONE of the veterans of engineering education has been taken from us by the death at eighty-four years of age of Professor H. J. Spooner. He was born in 1856, and opened his career as a teacher when he was only three-and-twenty. His technical education was acquired at the Royal School of Mines, and as an engineer under Loftus Perkins, and soon after completing it he gave a course of lectures to the staff and workers of the Royal Small Arms Factory at Enfield and the Waltham Powder Mills. It will be remembered that at that period there were few, if any, evening schools, but there still were what were known as Artisans' Clubs in many parts of the country at which lectures were delivered on technical subjects, often by men who subsequently made their mark in the world of engineering or had already done so. Spooner was obviously successful as a teacher, for in 1882 he was appointed principal Lecturer on Mechanical Science at the Polytechnic in Regent Street, which even at that time had won a name in the field of technical education. Four years later his position in the college was greatly improved when he became Director and Professor of Civil and Mechanical Engineering, a post which he retained till 1922, when he retired at the end of forty years' service. During that period he wrote a number of text-books of one kind and another, and at least one book on motoring, in which he took a keen interest.

But he will be principally remembered in recent years by the energetic campaign against noise which he pursued both in this country and America. There can be no question at all that it was largely owing to his persistency that the world became conscious of the ill-effects that noise was having upon humanity, and that scientific research into the subject was begun. He was selected in 1921

PROFESSOR H. J. SPOONER

to give the Chadwick Lecture, and took as his subject "Problems of Noise and Fatigue," but he, in fact, did more to force the matter upon public attention by copious letter-writing, both to the Press—THE ENGINEER included—and to private individuals. He served on numerous special committees on industrial management, industrial fatigue, &c., and wrote articles on a variety of subjects for the British and American Press. But, as we have said, he will always be remembered by what he unquestionably achieved by his campaign against noise.

### JOHN BARR

SHIPBUILDING has lost one of its greatest exponents of recent years by the death of John Barr, which took place at his home in Beckenham on Tuesday, December 10th, in his eighty-second year. After an active career for many years with the Vickers organisation, Mr. Barr spent a further fourteen years in the organisation of the industry and its various administrative and commercial developments.

John Barr was born at Kirkby, near Barrow-in-Furness, in 1859, and received his early education at the Commercial School in Barrow. Like the boys of those years he was introduced to business at a very early age, and joined the staff of the Barrow Shipbuilding Company, Ltd., following on in the service of the Naval Construction and Armaments Company, Ltd., the predecessors of Vickers, Ltd., at Barrow-in-Furness. He was thus associated with the earliest development of the Vickers undertaking at Barrow, and saw it develop from comparatively small beginnings to the period of activity and prosperity which was reached under the leadership of the late Sir James McKechnie and Sir Trevor Dawson. He served in all branches of the firm, and in 1927 was made a director and was given charge of the commercial department. Not only did he concern himself with the Barrow works, but he took a great interest in the reorganisation of Vickers' works in the South, especially those at Erith, both before and during the period of the last war. In 1923 he resigned from his position at Barrow, and in the following year the industry honoured him by electing him President of the Shipbuilding Employers' Federation, an office which he continued to hold with distinction until the end of 1927. Before and during this period his invaluable help was always at the disposal of the industry, and for many years he was an active member of the Central Board and the Executive Committee of the Federation. From 1928 until 1937 John Barr was Controller of the Shipbuilding Conference, as well as a director of National Shipbuilders Security, Ltd. He served on many Government Committees, and in particular was a member of the Committee of Inquiry appointed by the Industrial Unrest Commission in 1917 to look into the position of skilled men employed on munition work. In recognition of his many services he was awarded the C.B.E. in 1920.

In business his interests were not limited to Barrow, and while Vickers held an interest in Vickers-Petters, Ltd., of Ipswich, Mr. Barr was a director of that company. He was also for some time Vice-Chairman of the Iron Trades Employers' Association, and a director of Sir W. G. Armstrong-Whitworth and Co. (Shipbuilders), Ltd.

He retired from active participation in the executive and administrative work of the central organisation of the shipbuilding industry in 1937 and the esteem in which he was held by his fellow-shipbuilders was marked by the presentation to him of a portrait of himself painted by Mr. Howard Somerville.

## Sixty Years Ago

### THE VALUE OF CHEAP PATENTS

A PAPER entitled "On the National Value of Cheap Patents" was read before the Society of Engineers by Mr. Frank W. Grierson on December 6th, 1880. In a leading article which we devoted to it in our next succeeding issue, we congratulated Mr. Grierson on the lucidity of his style and on the effective manner in which he had exhibited his statistical information by means of diagrams. That, however, was the full extent of our praise for the author's literary labours. The paper, we said, bristled with so many politico-economical mistakes that we could not find space even to indicate them all. Mr. Grierson supported his argument in favour of cheap patents by advancing a set of propositions which he took as axioms. The United States, he said, were more prosperous than Great Britain. They were more prosperous because over 13,000 patents were taken out each year as against 2980 in this country. More patents were taken out in the United States because in that country a patent cost £7 as compared with £175 in Great Britain. As a secondary argument Mr. Grierson advanced the statement that each year 9000 working men of the best class emigrated to the United States because they could save £168 on the cost of the patents which they wished to take out. We joined issue with Mr. Grierson on all these points. Was it certain that the United States were more prosperous than Great Britain? It was undoubtedly true that misery existed at the moment in every great city of the Union and that not so many months previously the manufacturing districts of the States presented a picture of closed works, idle mills, and starving hands. Passing to the author's second "axiom," we said that the inventions which brought great wealth to a nation were not numerous. We could count on the fingers all those which had made Great Britain famous—the steam engine, the railway, the rolling mill and puddling furnace, the Bessemer and Siemens-Martin processes, the cotton mule and spinning frame, the power loom, and certain inventions used in the manufacture of chemicals. These inventions had been the main sources of the wealth, not only of Great Britain, but of the whole world. Not one of them had been invented in the United States. Not one really great invention had been made in the Union. The American people were pre-eminent as inventors of small things such as sewing machines, clocks, machines for pegging boot soles, Yale locks, and all manner of "notions." But great inventors did not grow on American soil. The country was still too young and in too great a hurry to do great things as yet. In spite of the cheapness of the American patent law, the country was unable to carry on any manufacture whatever at a profit without the aid of a heavy protective tariff; and our unprotected manufacturers, in spite of dear patents, competed successfully in foreign markets against United States products. We had more to say regarding the rest of Mr. Grierson's paper, but we may sum it up by quoting our conclusion: "If nothing more can be advanced in favour of cheap patents than Mr. Grierson has brought forward, then we assert at once, and every reasonable and unprejudiced man will assert, that the advocates of cheap patents have no case."

PRODUCER GAS FROM ANTHRACITE.—In the endeavour to find new outlets for certain low-volatile coals from South Wales, a process has been developed at the Fuel Research Station for the complete gasification of this type of coal in a normal water-gas plant.

# The Engineer

*DECEMBER 20, 1940*

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## RIVAL PREDICTORS IN WAR

To picture warfare as gun against gun, and tank against tank, seems natural enough, but not many think at the same time of the rivalry between the predictor mechanisms which are an inseparable part of the use of missile weapons. Even David must have made some estimate of Goliath's probable movements when using his sling! If the missile, whether bullet, shell, or bomb, is to be truly aimed, allowance must be made at the transmitting end for the range and the relative speed of motion of the target, since it is necessary that the missile should leave the transmitter in the right direction, both in azimuth and elevation, in order to reach the spot where the receiver will be by the time the missile arrives.

The ordinary shell or bomb cannot be corrected in its path once it has been discharged, and it is necessary that before discharge some predictor apparatus should be available for forecasting how much the target is likely to move during the next minute and what consequent allowances to make in range and bearing. In the case of great warships, the predictor apparatus is a highly complex piece of mechanism, taking up not a little space in the ship and requiring a great deal of attention. Whilst the ship fires, this mechanism makes a continuous plot of the enemy movements, and it matters little to that mechanism what those movements are—they may be in any direction and at any speed. It is true that there can be but one relative speed for the two vessels, but if the guns are of different calibre and muzzle velocity the allowances to be made will differ. It is a matter of tactics for the ships' commanders during the short time interval available to take what avoiding action they can. When a land battery fires at a ship the situation is much the same; although the battery cannot, it is true, change its position at will, its commander has the balancing satisfaction of knowing that it cannot be sunk by a hole below the water line. A different problem is provided when gun is pitted against torpedo, since the "times of flight" of the two missiles are so extraordinarily diverse, and the trajectories themselves so different; but the torpedo needs really a separate class of predictor of its own, since, unlike shell or bomb, it provides its own propulsive power as it goes along. Perhaps the most striking case of rivalry between predictor mechanisms is afforded in the contest between the bombing aircraft and the A.A. gun, especially when there are no clouds to interfere and no lack of visibility. For the contest to be vivid, the A.A. gun must have a sufficiently high muzzle velocity to reach in reasonable time the altitude at which the target aircraft is flying. If this time of flight be, say, 15 sec., and the air speed of the bomber 300 miles an hour, the latter will travel through the air no less a distance than 1¼ miles before the shell reaches its level. If the overall length of the bombing aircraft be 70ft., this will require an aim of no less than 100 lengths ahead; an emphatic indication of the immense opportunity the bomber has to take avoiding action. The corresponding allowance when naval vessels attack one another may be no more than a couple of lengths, a very different situation. This is the chief reason why A.A. gunnery is so difficult. The gunner's best chance arises when the aircraft is so set on its immediate objective that it refuses to take any avoiding action at all. This happy situation for the A.A. gun may be produced by the use on the aircraft of some bomb-sighting mechanism which necessitates during the approach to the target that the aircraft shall proceed on a straight run at a steady height. An example of this was seen in an automatic bomb sight produced in Germany some years ago, and there have been others produced since. Such a requirement as this cannot but play into the hands of the A.A. predictor, since it is the very form of motion which it is easiest to deal with. It is true that one can picture the construction of an alternative bomb-sight mechanism based on the hypothesis that the aircraft will fly on some curvilinear path instead of a straight one, possibly even changing height as it does so, but it can be no simple matter to design and build such an instrument, though once available it would certainly make the gunner's task a hard one. Some designers have aimed at a simple mechanism merely to show the bomb aimer at any moment exactly where his bomb would strike the ground, leaving it to him so to manœuvre the craft as to attack the desired target; no assistance is then given to the A.A. gunner, provided, of course, that the settings on the sight can be made sufficiently in advance of the approach to the target.

Experts in such mechanisms must have a difficult task in deciding between the many alternatives available, complicated as the selection is and must be by the consideration that the apparatus which happens to provide the easiest and simplest task for the bomb-sight operator may, if one is not careful, prove also to ease the task of the A.A. gunner on the ground.

### A Little More Than Good Enough

IN the Presidential Address which he delivered to the Junior Institution of Engineers on December 14th Lord Falmouth devoted a good deal of space to a subject which has received our attention on several occasions. If there is one thing more than another upon which British engineers pride themselves it is the high quality of their products. It is almost a tenet with those engaged in the export trade that Great Britain should refrain on open markets from competition with other nations in cheap productions, and that it should concentrate its attention only on those of the highest standard. There may justly be two opinions on the wisdom of this contention. It is well known that other nations have often secured orders because purchasers were quite satisfied with something below the high standards followed by British engineers. It has therefore sometimes been advocated that instead of a single B.S.I. specification for a commodity, there should be two, the second covering a lower grade than the first, but without sacrificing the essential qualities. This proposal calls for the closest attention when the nation is at war, and when the highest possible rate of output is essential. Nothing that administers to efficiency must be sacrificed, but at the same time it is essential that some of the refinements to which we have grown accustomed in times of peace should be given up.

It is familiar knowledge that the Services have not only insisted rigorously in the past on the highest class of accuracy and the highest qualities of materials, but have also demanded a degree of finish sufficient to give that smartness of appearance so beloved by them. It is probable that there is a not inconsiderable psychological value in appearance. A smart ship or a smart regiment may perhaps be more efficient than one that is less given to spit and polish. But in the mechanised warfare of to-day that quality is overridden by the necessity to secure rapidity of output, just as the recruiting value of smart uniforms has had to give place to the purely utilitarian merits of the now familiar battle dress. Efficiency for the purpose intended is the only thing that counts; everything else that delays output, either by workmanship or quality of material, must be sacrificed. In war, as Lord Falmouth rightly said, "quantity and speed of output are of overwhelming importance, and, coupled with them, is the fact that not a single man-hour more than is absolutely necessary should be spent on any job." Limits and clearances, he added, should be as great as possible, and the rule for finish should be "just as high as is absolutely necessary to secure efficiency, and not a scrap more." Touching upon Service requirements, the President said: "In normal times there is always a tendency on the part of the Services to aim at a 100 per cent. solution of a given problem. Now, the engineer knows that whilst it may be comparatively easy to attain, say, an 85 per cent. solution, the difficulty of that 'something extra' is great, and long delays, running perhaps into months, may ensue before success is achieved. Indeed, it would sometimes appear better to be content with the 85 per cent. now, rather than wait for a better result later. Weeks and months in war have a habit of sometimes being decisive ones." This is all fundamentally true, but it is very difficult to convince the Services, particularly senior officers, that something different from what they have been brought up with and grown accustomed to may be amply good for the purpose to which it has to be put. Lord Falmouth suggested that the watchwords for engineers to-day should be "elasticity of thought, adaptability of mind, readiness to alter preconceived ideas when necessary, and willingness to improvise with new methods, new tools, and strange materials." We venture to suggest that it is not the engineers alone who need these watchwords. The people for whom they are working are generally more conservative in their views than the most conservative engineer.

Whoever has the temerity to propose that there should be a revision of the design of war products in order to decrease the cost or accelerate the output lays himself open to the charge that he is trying to foist off inferior products upon the militant services. The competent engineer does nothing of the kind. Having, in the first place, satisfied himself what qualities are essential, he takes steps to ensure that in those qualities his products shall be as nearly 100 per cent. perfect as his means will allow. Then he sets to work upon all the details of secondary or tertiary importance, and prunes away all those that are redundant. He does not insist on an A 1 fit where a B 2 will satisfy the conditions; he does not insist on a special material where a normal material will meet the requirements; he does not insist on polish where paint will do. The final product is just as serviceable as the original product, but it may be 10, 20, 50, or even 80 per cent. more quickly producible or cheaper than the original. Moreover, he takes into account, if he is allowed to do so, two

other factors which affect price and rate of output. The first is the degree of accuracy of effect desirable and the probable life under war conditions. For example, it may be in the highest degree desirable that a marksman's rifle should be extremely accurate; but obviously the accuracy of a machine gun which is intended to spray bullets over a large area may be of somewhat lower degree. Again, it is equally clear that it is wasteful to give war materials which are going into immediate service, and have therefore an expectation of life that can be numbered in days or hours, the same endurance as that provided for when war is a remote contingency. "Good enough" is generally an excuse for poor workmanship, but rightly and precisely understood it expresses the degree of excellence which should be sought in times of war—only it is well to make it a little more than "good enough" to cover slight lapses.

### The New Scrap Order

No surprise was occasioned by the issue by the Minister of Supply of the Control of Iron and Steel (No. 14) (Scrap) Order, 1940, making fresh prices and regulations for the control of iron and steel scrap. The last Order relating to scrap was published on February 29th, and since then railway freights have been increased and other higher charges have had to be met by suppliers. The price advances which range over the whole of the categories contained in the Schedule to the Order, excepting in a few instances, represent the increases in railway freights which took place on December 1st. In addition to the alteration in prices, there have been a few changes made in the Order itself, when compared with the preceding Order. For instance, in the Order issued last February it was stated that "no person shall dispose of or agree to dispose of any materials situate in the United Kingdom," whilst the current Order prohibits any person acquiring or agreeing to acquire "any" material mentioned in the Schedule, except under a licence, or a special or general Direction of the Minister of Supply.

Recently, rather easier conditions have developed in the scrap market than when the previous Order was made, and under ordinary trading conditions this would scarcely have been considered an opportune time for raising prices; but when the market is controlled by a complicated system of licences and governmental regulations, the ordinary laws of supply and demand do not operate with the same freedom. Imports of scrap from America and the nation-wide campaign for the collection of scrap in this country have done much to cause the accumulation of liberal supplies for the steel works, but at the same time suppliers of scrap to the consumers have had to meet higher costs in several directions, and if the market has to be controlled and regulated by the Government, it stands to reason that a fair margin of profit should be afforded to the seller. This policy is further borne out by the provision in the new Order for *bona fide* iron and steel scrap merchants to increase their charge to 3¾ per cent. above the official prices, whereas under previous Orders they have only been permitted to add 2½ per cent. In this, scrap merchants may consider themselves fortunate, since in no other section of the iron and steel and non-ferrous metal trades are the functions of the merchants recognised to the same extent by the Minister of Supply.

# The Engining of Highly Powered Ships*

By Sir STEPHEN J. PIGOTT, D.Sc.

No. I

### Reciprocating Engine

UNTIL the beginning of the present century the reciprocating type of steam engine with steam supplied generally by boilers of the cylindrical fire-tube type satisfied all demands for highly powered ships, and it would seem that, next to the period of the full-rigged sailing ship, the romance of sea-going held most strongly in this era, and the interest in mechanical propulsion reached the highest pitch through the stimulus of the international struggle for speed in Atlantic crossings, and the honour of holding the much-coveted Blue Riband. For approximately three score years this honour was successfully maintained by the progressive development of propulsion in vessels of British and American ownership, changing hands in 1897, when the performance of the "Campania" was surpassed by that of the German-owned "Kaiser Wilhelm Der Grosse." Then followed the "Deutschland" and the "Kaiser Wilhelm II" to retain this coveted honour in German hands for a period of some ten years.

These multi-cylinder engines marked the highest power and development of the steam reciprocating engine, and may be considered the acme of the mechanical engineering art of the nineteenth century. It is a matter of interest that the "Kaiser Wilhelm II" was a twin-screw vessel having two three-crank, quadruple-expansion engines on each shaft.

Table I enables ready comparison of the general features and particulars of these mammoth mechanisms attaining to approximately 50ft. in height.

Earlier mention was made of the interest attaching to the visible motion of massive crankshafts turned by massive connecting-rods responding to the reciprocating movement of massive pistons, and it may be considered ironical that this very massiveness should become the limiting factor in development. The rapid reversal of the direction of travel of piston, piston-rod, and crosshead; the difficulty of balancing both the vertical and horizontal forces; the variation of torsional stress in the transmission of power through the shafting; the limitation of the effective employment of the attainable vacuum in the condenser by reason of the practical limitation of the expansive capacity in low-pressure cylinders—all of these, together with the necessary extent of engine-room for suitable accommodation, served to define the limitation of power.

### The Coming of the Marine Steam Turbine

It is a far cry from the earliest recorded application of the rotative force of steam pressure, at the beginning of the Christian Era, in the primitive working of virtually a toy mechanism, to the practical application of this same force in the latter years of the nineteenth century as a real rival to the then highly developed reciprocating steam engine; it was at this critical moment in marine engineering history that the Hon. C. A. Parsons astonished the world with the performance of the "Turbinia," and opened the door to a new era in marine propulsive power development, the limits of which have yet to be realised.

From various records it would appear that this principle of rotative force did not lie entirely dormant throughout those centuries, and there is evidence that the possibilities were recognised by James Watt. In explanation of the long delay in the practical application, it has been stated that the machine tools available in those earlier years were not adequate to give the degree of accuracy in finish necessary in an engine dependent upon high speed of rotation for economical service. In support of this explanation it may be contended that developments, even in recent years, indicate that progress in the perfecting of machine tools has greatly influenced, or has actually dictated, the progress in the development and transmission of power.

In his lecture entitled "Sir Charles Parsons and Marine Propulsion," given before the Institution of Mechanical Engineers in 1938, Mr. Stanley S. Cook—see THE ENGINEER, December 9th, 1938—has ably and very fully covered the earlier developments of the reaction turbine for ship propulsion, and it is not intended to attempt in this lecture any elaboration. It is not, however, inappropriate that mention be made of the similar development of the marine impulse turbine by Charles G. Curtis, begun in the United States of America in the early years of the present century, and subsequently extended to the propulsion of notable ships constructed also in Great Britain and on the Continent of Europe.

The propelling installations of the "Lusitania" and the "Mauretania" must forever hold place as the most highly powered type of direct-coupled turbine drive in merchant vessels. For the engineer of to-day to appreciate fully the development of propulsion of these mighty ships, it is necessary that he should realise the genius, the courage, and the tenacity of the late Sir Charles Parsons, beginning with the construction of the radial-flow turbine of the "Turbinia," persevering through the misfortunes of the "Cobra" and the "Viper," and progressing with relatively low-powered naval and mercantile installations to the "Carmania" of 21,000 S.H.P., and then the drastic increase to the installations of 70,000 S.H.P. fitted in the "Lusitania" and the "Mauretania."

### Advance from 9000 to 70,000 S.H.P.

To appreciate fully just how meteoric was the rise of the marine steam turbine, it should be noted that whereas the power of reciprocating installations increased from 5000 to 45,000 I.H.P. in a period of fifty years, the power of turbine installations increased from about 9000 to 70,000 S.H.P. in a period of about five years.

It may be contended that the confidence of Sir Charles Parsons was well supported by the fulfilment of his expectations in earlier achievements, and that this drastic increase was a matter of degree which could be substantiated by trustworthy calculations; also it may be recalled that this enterprise proceeded only after receiving the blessing of a committee of eminent engineers called together by the Cunard Company for the purpose of assessing what reasonable certainty there was of success. It may also be contended that the other associates of this enterprise, namely, the owners and the builders, had also the findings of this committee of experts to fortify their trust in the recommendations of Sir Charles Parsons; but the engineer of to-day would be guilty of ingratitude did he not appreciate the enterprise and foresight of the then chairman of the Cunard Company, the second Lord Inverclyde, in specifying turbine propulsion for the "Carmania," while the question of the propulsion of the "Lusitania" and "Mauretania" was still under consideration, and it would seem that he must have fully realised even at that early day that only through the utilising of pro-

Table I

| | "Campania" and "Lucania." | "Kaiser Wilhelm Der Grosse." | "Deutschland." | "Kaiser Wilhelm II." |
|---|---|---|---|---|
| Length (between perpendiculars) ... | 601ft. | 625ft. | 662ft. 9in. | 678ft. |
| Displacement, tons ... ... ... ... | 18,000 | 20,880 | 23,620 | 26,500 |
| Type of engine ... ... ... ... ... | Five cylinder Triple expansion | Four cylinder Triple expansion | Six cylinder Quadruple expansion | Four cylinder Quadruple expansion, 2 engines in tandem |
| Number of cranks ... ... ... ... | 3 | 4 | 4 | 3 |
| Diameter of cylinders in each engine... | 2 at 57in., 1 at 79in., 2 at 98in. | 1 at 52in., 1 at 89·7in., 2 at 96·4in. | 2 at 36·61in., 1 at 73·6in., 1 at 103·9in., 2 at 106·3in., | 1 at 37·4in., 1 at 49·1in., 1 at 74·7in., 1 at 112·2in. |
| Stroke ... ... ... ... ... ... ... | 69in. | 68·8in. | 72·8in. | H.P., 1st I.P., and 2nd I.P. = 70·8in. L.P. = 72·8in. |
| Number and type of boilers ... ... | 12 double ended, 1 single ended | 12 double ended, 2 single ended | 12 double ended, 4 single ended | 12 double ended, 7 single ended |
| Steam pressure ... ... ... ... .. | 165 lb. | 178 lb. | 220 lb. | 225 lb. |
| Total heating surface (square feet) ... | 82,000 | 84,285 | 85,468 | 107,643 |
| Total indicated horsepower ... ... | 30,000 | 30,000 | 36,000 | 43,000 (44,600) record voyage |
| Type of draught ... ... ... ... .. | Open stokehold | Open stokehold | Open stokehold | Open stokehold |
| Highest mean speed on Atlantic passage ... ... ... ... ... .. | 22·01 knots | 22·79 knots | 23·36 knots | 23·58 knots |

* Sir Charles Parsons Memorial Lecture, North-East Coast Institution of Engineers and Shipbuilders, December 17th.

pulsion by turbines could the purpose of these great vessels be achieved.

Through the kind permission of Cunard White Star, Ltd., the following abstracts from the deliberations of the Cunard Committee appointed to consider and report upon the advisability and practicability of adopting turbine engines instead of reciprocating engines in the new fast steamers are given :—

The Committee are aware that the makers of several types of turbine engines are prepared to make machinery of their own type for marine purposes. In the course of the inquiry, it soon became apparent to the Committee that for these large ships the only type requiring serious attention was the Parsons', this being the only one with which any reliable experience afloat has been obtained.

At the time the Committee were appointed there was little information available as to the relative economy of turbine engines and reciprocating engines.

In order to determine the mechanical difficulties likely to present themselves in the construction of turbines of sufficient size to develop the required power, and also to deal with the general question of turbines being fitted in these vessels, the Committee have examined the drawings which have been prepared by the Parsons Marine Steam Turbine Company. Several modifications in the design have been suggested by the Committee, and the drawings have been altered accordingly.

The Committee point out that the question on which they are asked to give an opinion is one involving very great changes in the ordinary practice of marine propulsion. At present, few vessels have been fitted with turbine machinery, and the turbines in these vessels are of moderate size only. The most powerful set of marine turbine machinery in use at present is that fitted in the steamship "Queen," employed on the Calais and Dover service, which has about 9000 H.P. applied through three shafts. The proposed arrangement of turbine machinery for the new large ships provides for over 60,000 H.P. applied through four shafts. The Committee wish to emphasise the fact that one of the questions they have to answer is whether they would recommend advancing from machinery of about 9000 H.P. to machinery of over 60,000 H.P. with a type of engine which has only recently been brought into use afloat, or, in other words, from turbine machinery developing about 3000 H.P. per shaft to turbine machinery to develop over 15,000 H.P. per shaft. Increase of size with reciprocating engines has only proceeded slowly, and about forty years were occupied in passing from a horsepower of 5000 to a horsepower of 20,000 on one shaft.

As the engines of the highest powered vessel afloat develop about 40,000 H.P., the question now under consideration involves an advance in the total horsepower in one ship from 40,000 to over 60,000. The Committee recognise that the experience gained in the design and manufacture of such high-powered reciprocating machinery will be of service in dealing with large turbines.

On the basis of Mr. Froude's report, for a vessel of about the dimensions given, to obtain a speed of 25 knots the horsepower of the propelling machinery to be installed, whether reciprocating engines or turbines, are fitted, should be between 65,000 and 70,000. The Committee see no reason why turbines of this power could not be constructed ; but they are not in a position to express an opinion as to whether the machinery and boilers can be installed in ships of the dimensions given. Although such turbine machinery would be very much larger than any machinery of that type at present at work, the Committee are of opinion that it could be applied with reasonable expectation of success and absence of vibration, whereas with reciprocating engines, placed in the only available positions in the ships, the vibration would be troublesome.

The question of vibration if reciprocating engines were fitted has been considered, and it had been found that the engines could not be perfectly balanced even by the largest balancing weights it would be advisable to use. With turbines, however, the vibration due to the engines would be practically nil.

The advantages which turbine engines would possess over reciprocating engines for the new fast steamers are :—

(1) Saving of weight.
(2) Practical absence of vibration.
(3) Reduction of the engine-room staff.
(4) Reduction in expenditure of engine-room stores.
(5) All machinery, except the eduction pipes and tops of the condensers, below the water, thus rendering the ships more suitable for Admiralty requirements as armed cruisers.
(6) Reduction in cost of upkeep of engines.
(7) The diameters of the shafting outside the turbine being less than those of some shafting in use. If reciprocating engines were fitted the shafting would be larger than any with which experience either in manufacture or in use on board ship has yet been obtained.

The disadvantages of the turbine engines, as compared with reciprocating engines for these ships, are :—

(1) The limited amount of experience yet obtained with turbine engines.
(2) The great weights of parts to be dealt with in manufacture and overhauling, the heaviest pieces each weighing about 100 tons.
(3) The necessity for providing special lifting gear for these heavy weights, and arranging for the removal of the decks overhead to permit of overhauling on an extensive scale being carried out when required.
(4) The necessity for the use of four shafts with four propellers, and the fact that the only data at present available from which the efficiency of this arrangement can be judged are those afforded by tank experiments. The Committee understand that these tank experiments will be supplemented by experiments with the launch before mentioned.

The manœuvring of these ships will necessarily present special difficulties on account of their great weight and high speed, whichever type of machinery would be fitted. The Committee have considered the question of the probable efficiency of the turbine in this respect, and see no reason for doubting, on the performance of existing turbine vessels, that with the intended provision of power in the reversing turbines, satisfactory results should be obtained.

The Committee are of opinion that it would be justifiable to adopt Parsons turbines for these vessels, despite the absence of experience in connection with turbines of such large size, although, as explained above, the step is unavoidably a large one.

In reviewing to-day the conditions obtaining in the last decade of the nineteenth century and in the first decade of the present century, it would seem that had this Cunard Committee demurred in recommending the adoption of steam turbine propulsion, then the "Lusitania" and "Mauretania" would not have eventuated, or, at best, this project of regaining the supremacy in Atlantic crossings must have been deferred until such later years, when more gradual development and progress would justify this great enterprise.

The Cunard ship "Carmania" cannot be truly rated as a highly powered vessel with a total shaft horsepower, approximately one-half of the power developed by the reciprocating engines of the "Deutschland" and "Kaiser Wilhelm II," but with the building of the turbine installation for the "Carmania" immediately preceding the constructing of the turbines for the "Lusitania" and the "Mauretania," much valuable experience, both in matters of design and of production, was gained thereby.

### Combination of Reciprocating Engine and Turbine

The advocates of the reciprocating steam engine were not dismayed by the success of the all-turbine ships, and there existed a strong conviction that the higher pressure range of expansive power of steam could be more economically employed in the cylinders of the reciprocating engine than in the high-pressure units of the all-turbine system, while admitting the more effective employment of the lower pressure range and the fuller use of available vacuum in the turbine. From such deduction resulted the reciprocating engine-turbine combination drive, with endeavour concentrated more fully on increased economy in the use of fuel than on superiority in power development.

Among highly powered ships, the "Olympic" and "Titanic" are outstanding examples of this combined system with a four-cylinder triple-expansion engine on each outer shaft and a low-pressure turbine on the centre shaft taking the steam exhausted from both reciprocating engines. This system, although more recently employed in the later "Laurentic" and in the "Britannic," has not gained wide popularity, it being contended by many that while the rate of fuel consumed per horsepower developed showed improvement over the all-turbine system, the propulsive effort on the ship does not show a similar improvement, due to the lower propulsive efficiency of the faster-revolving turbine-driven centre propeller.

### Turbine Development in Naval Vessels

While emphasising so greatly the rapid development of the direct-turbine drive in merchant vessels, it is not intended to minimise the similar, though somewhat slower, progress made with this system of propulsion in naval vessels. The battleship "Dreadnought" must always hold high place, especially as an example of the adaptability of the turbine to the problem of armour protection of the vital machinery parts of a warship installation. With the installations of reaction turbines in the battle cruisers "Lion" and "Queen Mary" and in the battleships "Queen Elizabeth," "Warspite," and "Malaya," and the installations of impulse turbines in the battle cruiser "Tiger," the battleships "Barham" and "Valiant," and in the still more powerful battle cruisers "Repulse" and "Renown," the application of the direct-connected turbine progressed in ships of His Majesty's Navy to a power level much in excess of the highest achieved with this system of power transmission in merchant vessels.

### Direct Turbine Drive

In tracing or following the development of the direct turbine system of propulsion, a natural analogy with the development of the reciprocating engine in the endeavour for greater economy in fuel is suggested as being of passing interest. The single high-pressure unit exhausting to a single low-pressure unit may be considered analogous to the two-cylinder compound reciprocating engine, while the single high-pressure turbine unit exhausting to a pair of low-pressure turbines may be termed a three-unit compound system. In s.s. "Carmania," in smaller powered installations of cross-Channel ships and in comparatively low-powered naval vessels, there were many examples of this three-unit compound system ; but there appears no instance of this system finding favour in highly powered ships. Similarly, in the propulsive system adopted in the "Imperator" ("Berengaria"), the "Aquitania," and the "Vaterland" ("Leviathan"), the arrangement employed of single high-pressure, single intermediate-pressure, and two low-pressure turbines is similar in purpose to the four-cylinder, triple-expansion engine. With installations such as those employed in the "Lusitania" and "Mauretania," the endeavour for higher economy of fuel was limited by the size of the turbine units, which condition dictated the further subdivision of the steam expansion range. The building in Germany of the "Imperator" and "Vaterland" and the building of the "Aquitania" in Great Britain at about the same period—all of moderate power—clearly indicates endeavour for increased economy in the use of fuel and increase in revenue earning, rather than any effort to surpass the performance of earlier ships in the speed of the Atlantic crossing. It has been freely stated by the owners that the "Aquitania" has proved a highly successful and satisfactory enterprise, and, with minor turbine adjustments and with boilers converted to oil burning, she is now, after more than a quarter of a century, in constant operation, maintaining a higher speed consistently than ever before in regular service.

*(To be continued)*

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**Orsk Metallurgical Combine.**—Some 11 miles from Orsk, in the Urals, preparatory work is in progress for the building of the Orsk Metallurgical Combine. The first section of this Combine will consist of two blast-furnaces, two coke batteries, part of a steel foundry and the corresponding ore mining enterprises. This first section is scheduled for operation in 1943, and the whole of the Combine is to be completed by 1945. Two thermo-electric power stations are also to be built. As supplies of water from the River Ural are insufficient for the requirements of the Combine, it has been decided to build a big reservoir at Iriklin, 50 miles from Orsk. Survey work in connection with this reservoir is already in progress. The Orsk Metallurgical Combine as a whole will have four super-powerful blast-furnaces, each of a volume of 45,900 cubic feet, with an aggregate output of 1,200,000 tons of pig iron a year. The projected capacity of the open-hearth shop and rolling mill is 1,000,000 tons of steel and 800,000 tons of rolled metal. The Combine will include a coke-chemical works (capable of producing two million tons of coke a year), as well as ore mines, enriching and agglomeration plants.

# Letters to the Editor

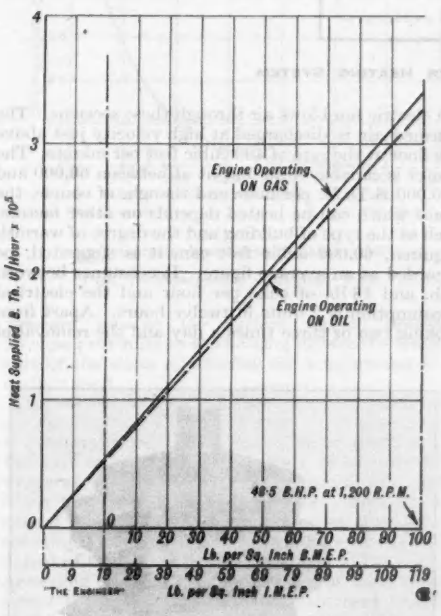
*(We do not hold ourselves responsible for the opinions of our correspondents)*

## TOWN'S GAS FUEL FOR PETROL ENGINES

SIR,—My attention has been drawn to the paper by Mr. E. A. C. Chamberlain, Ph.D., D.I.C., published in your journal, and the letters criticising the gas mixture strength given in the paper. Mr. Chamberlain himself has pointed out that he was dealing with existing petrol engines and their conversion to run on town's gas, and that maintaining, as near as possible, the power output of the engine was of primary importance, and therefore no comment is necessary from myself.

The general question of mixture strength does, however, merit some comment, and though various statements have been made with regard to obtaining higher efficiencies with extremely weak mixtures, our experience is contrary. In the case of a series of experiments on a "National" high-compression gas engine, tests were made from full load to no load with quality governing (that is, throttling on gas only), and the mixture strength at full load was found to be 5·7 air to 1 of gas, and at no load 11·88 of air to 1 of gas, and while the optimum consumption was obtained at full load, the no-load consumption was 44 per cent. of the full-load consumption. This was in spite of the magneto being advanced 30 deg. earlier than full-load setting. (This is automatically controlled on "National" high-compression gas engine.)

The mixture strength was increased at no load to


Engine Operating ON GAS
Engine Operating ON OIL
48·5 B.H.P. at 1,200 R.P.M.
Heat Supplied B. Th. U./Hour × 10⁵
Lb. per Sq. Inch B.M.E.P.
Lb. per Sq. Inch I.M.E.P.
"The Engineer"

8·5 of air to 1 of gas, and the no-load figure improved to 27 per cent. of full-load consumption. (I must state, however, that the ignition advance over full-load setting was the same in each case.)

The latest tests with constant mixture ratio from no load to full load gave a straight-line total consumption graph equal to the best diesel practice, as shown by the following figures (see graph) :—

*48·5 B.H.P. Engine, 1200 r.p.m., 14·7 to 1 Compression Ratio*

| | |
|---|---|
| Full load consumption in B.Th.U. per hour | 3·4 × 10⁵ |
| No-load consumption in B.Th.U. per hour... | 0·54 × 10⁵ |
| No-load consumption in per cent. of full load | 16 |

*The Same Engine as an Oil Engine*

| | |
|---|---|
| Full load consumption (0·365 lb. per B.H.P. per hour) ... ... ... ... ... ... ... | 3·28 × 10⁵ |
| No-load consumption ... ... ... ... ... | 0·522 × 10⁵ |
| No-load consumption in per cent. of full load | 15·85 |

It will be seen from the above figures that if plotted against I.M.E.P. in pounds per square inch the zero consumption in each case would meet at zero I.M.E.P., and one would expect this with perfect combustion and the same engine in each case, as the mechanical efficiency should be the same, as the cylinder pressures are identical. This would give a mechanical efficiency of 84 per cent.

I expect it may be pointed out that ignition advance with weak mixture (*i.e.*, 11·88 to 1) was insufficient, but I disagree, as a heat balance sheet showed that unaccounted-for heat units amounted to 15·5 per cent., after making allowance for radiation. It should be noted that with quality governing the exhaust temperature falls almost as low as on a diesel engine, but with quantity governing (*i.e.*, constant mixture strength) the exhaust temperature is almost the same at all loads.

The above also answers Mr. G. K. King with regard to gas engine efficiency at light loads. The high-compression gas engine must not be confused with the dual fuel engine (*i.e.*, gas engine with high compression ratio using oil for ignition). This engine has a poor efficiency at light load, owing to the mixture being so weak that some gas goes through unburnt. If stratification could be achieved then the efficiency would be higher with this latter form of governing, but diffusion is an advantage at higher loads.

J. JONES, A.M.I.M.E.,
Chief Engineer.

The National Gas and Oil Engine Company, Ltd., Ashton-under-Lyne,
December 9th.

## NIGHT BOMBING

SIR,—*Apropos* your leading article last week, may I recall an old limerick which contrasts the scientist with the practician ?

"There was a young lady of York,
Who swallowed a wine-bottle cork,
In this sad emergence
They sent for three surgeons,
But the cook got it out with a fork."

December 16th. ANON.

## MANNERS AS A BUSINESS ASSET

SIR,—Your article attacking certain quotations taken from an essay printed in a recent issue of *The Economist* is, I think, insulting to your intelligence. In the passages quoted by you there was no mention of "good manners," but habits of dress, accent, and correctness were referred to as qualifications not stressed by "the poor boys' schools." Let me inform you that good manners are taught and enforced in the Government schools, also that the proportion of boys speaking good and correct English is as high as that of the public schools, remembering that the so-called "Oxford accent" is just as incorrect as the "Cockney."

As regards correctness and habits of dress, it is preposterous that one man should secure a position before a slightly more efficient candidate just because he knows the best wines and which to drink before dinner, and that sort of thing, which, you must admit, is more a qualification for a "playboy." To wear a top hat on certain occasions may look smart (some people look quite grotesque !); but remember, "a healthy skin often covers a rotten orange." All the rules for dress, the choosing of dinners, &c., are man-made, and suitably altered by "old public school boys," and are not, therefore, a suitable base for criticism.

I agree that courtesy, especially with regard to age and sex, is an ideal to be aimed at by everybody, and you will find that this aspect of good citizenship is enforced in Government schools ; but there, again, this virtue was not mentioned in your quotations from *The Economist*. It seems that you have grabbed the first available article pointing to a new and better method for education, *i.e.*, the same education for rich and poor, in order to "bolster" up the public schools, and the present unfair, inefficient, and ridiculous system for organising Britain's brain power.

In conclusion, may I say that I am not a product of "the poor boys' schools," and therefore my views are not biased, as you most probably have thought, by any sense of having had an inferior education. R. H. PADDON ROW.

Glasgow, December 9th.

SIR,—I have read with particular interest your leading article on "Manners as a Business Asset," and am in complete agreement with it. Frequently men of ability and of high technical attainments fail to make their mark solely because they lack those good manners, that sense of correctness, that polish and other characteristics, with a result that they experience a feeling of inferiority, which often is covered by a boorish attitude that is not tolerated. If we cannot send "a lot of poor boys to the rich boys' schools," surely it is not beyond the bounds of possibility so to modify the outlook of our schools that good manners are inculcated from the start. It will, however, be necessary to begin high up, for at the present time many of the masters regard good manners and correctness of speech as mere "snobbery," an attitude readily copied by the scholar. Engineers would be well advised to ponder your remarks. GEORGE W. TRIPP,

December 10th. F.C.G.I., M. Inst. C.E.

## PLANNING FOR THE FUTURE

SIR,—I welcome Mr. S. T. Bolson's letter, for I am no whit behind him in hoping, and in a small way striving, for a happier post-war world, but I have seen the fighting men of two earlier wars come home to be fêted and forgotten, and have heard the same pious hopes expressed on every hand during the struggle, only to see the country sink back into the old embittered striving for existence, and have small faith in the cure by "Planning for the future" from such observation of the past.

It is necessary, however, to define this elastic word "planning." Naturally all firms and individuals alike are thinking ahead to some extent, so as not to be caught napping should peace come suddenly, but the "planning" to which my letter of November 5th referred applied to those grandiose schemes which have been evolved in totalitarian countries and are an element of National Socialism, and which embody ideals which have been absorbed by certain powerful financial interests in this country, whose leaders have adopted the word for their slogan. Such schemes, however altruistically advanced, end inevitably in the regimentation of the people and the further enrichment of the planners.

Planning is not new. After the last war it resulted in a veritable spate of amalgamations. Banks, railways, engineering, catering, and many other branches of finance and industry, rushed into huddles, resulting in the formation of groups, trusts, and combines, for the elimination of competition and to the undoing of the small trader and the individualist. Hence our deplorable unemployment and the misery of the past twenty-five years, for elimination of competition of a healthy order must logically recoil on the public.

At that time, rightly or wrongly, I felt and endeavoured to preach that State-aided emigration, while the bond of common war service was strong, was the solution of our troubles, but our leaders gave us the dole, and the opportunity was lost. I believe it will offer again, however, and this time we may seize it ; the evacuation of children to overseas may be of inestimable value here.

To scatter and occupy undeveloped areas is in accord with Nature, while "planning" to extend the bone to feed the ever-increasing pack is an artifice which must finally break down. It is bound up chiefly with industrialism and industrialism has been overdone.

I share with Mr. Bolson a distaste for bureaucratic red tape and muddle as we know it, but why not amend the bureaucracy ? If its members were freely elected by popular vote they would at least have no axe to grind, and, like the judiciary, would be concerned only with the administration of their department, and might be removed by public opinion if they failed in their duties. Thus we come back to Plato's ideal of government by a class trained to govern, which I certainly hold preferable to government by the power of wealth, which industrial planning offers as the alternative. In the pursuit of liberty and happiness, more than mere wages is involved. S. P. C.

December 15th.

## RENEWAL FEES ON GERMAN PATENTS

SIR,—For a considerable number of years renewal fees on German patents have ranged from approximately £2 11s. to £85 9s. (at the pre-war rate of exchange), whereas renewal fees on British patents range from £5 to £16. Thus, for the final renewal fee on a German patent a Britisher has to pay approximately £69 9s. more than a German pays to us for the corresponding fee on a British patent. We think this state of affairs needs rectifying at once.

If it be objected that we cannot discriminate between German nationals and other nationals in this matter, what about trade agreements which discriminate between nationals of different countries ?

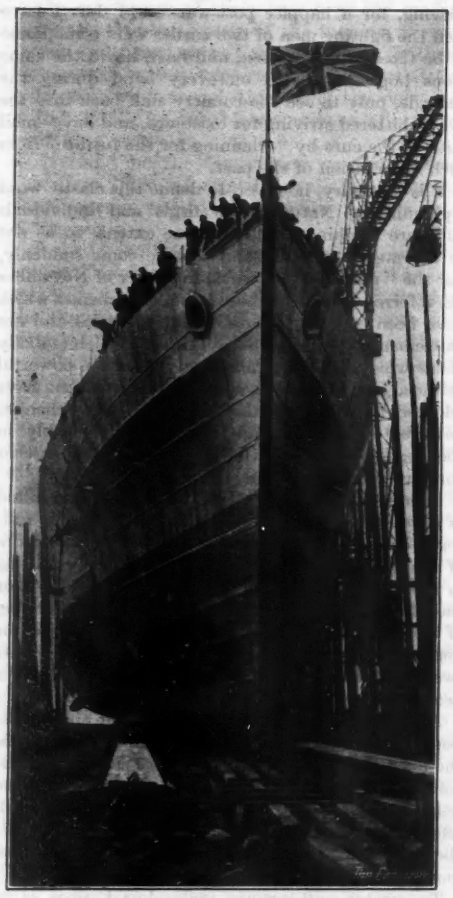
GEE AND CO.

London, December 13th.

THE LATE MR. LEONARD BURBIDGE.—We regret to learn from Blackstone and Co., Ltd., of Stamford, Lincs, of the sudden death, which took place on December 1st, of Mr. Leonard Burbidge, the firm's London manager. Before joining the firm Mr. Burbidge spent several years in the U.S.A. as manager of the technical sales staff of Peet and Powers, Inc., of New York.

## The Launch of a British Warship

BEFORE the war it was our duty and privilege to attend and to chronicle the launches of the many fine naval vessels which were added to the Royal Navy. The war has imposed a silence with regard to the important ships which are quickly being built and completed for the Admiralty. But from time to time, however, news of the successful launch of a



LAUNCH OF A WARSHIP

naval vessel from one of the many shipyards somewhere in Great Britain reaches us.

In the accompanying illustration we illustrate the successful launch from one of our shipyards of a new warship. The ship, with the Union Jack flying, was sent on her way by Mrs. Fraser, a lady of eighty-four years of age, who is the mother of Vice-Admiral B. A. Fraser, Controller of the Navy and the Third Sea Lord. The launch, like many others which have taken place from the same shipyard, was a perfect one, and the ship was quickly brought round to the fitting-out basin so that work on her could be resumed. In connection with this particular ship it can be stated that during the early stages of its construction the Admiralty learned from naval action elsewhere lessons which only war can teach, and that as the result of this new knowledge changes were made and improvements effected. When she is commissioned the ship which has just been launched should be one of our finest fighting ships, both in defensive and offensive warfare.

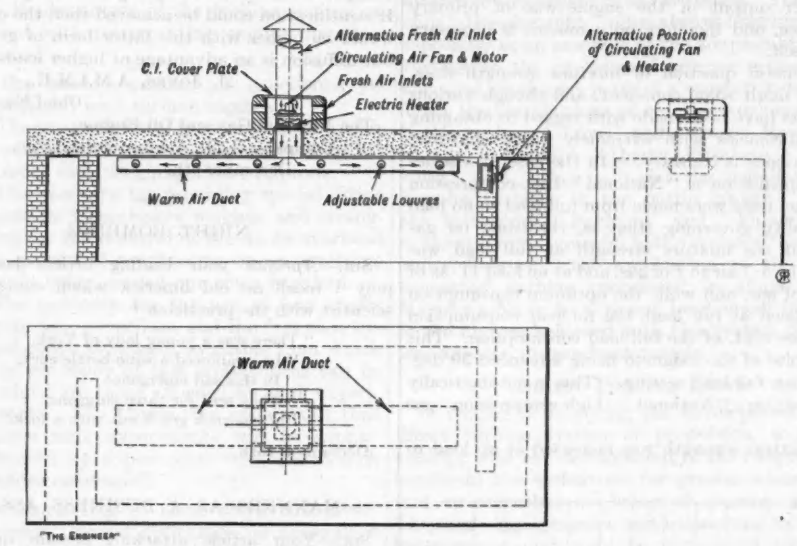
Any delay which may have occurred in the building of the ship will, we are informed, be more than made up in the time which will elapse before she is completed and handed over. The men who have built the ship are keen to see more ships launched as they know that they are contributing to the building up of the Royal Navy, which is doing so much to ensure speedy victory.

At a northern shipyard another warship was recently launched which will be added to the Royal Indian Navy. At this launch, Sir Arozkhan Noon, the High Commissioner for India, said that it had always been a disappointment to India that she did not have a Navy commensurate with her needs or in accordance with her great and proud Army.

## Heating Air Raid Shelters

Now that the winter is fast approaching, the problem of heating air raid shelters is one demanding consideration.

A heating unit made by Controlled Heat and Air, Ltd., of Smethwick, may be placed external to the building and the heated air brought into the space to be heated by a suitable system of ducting. This ducting, inside the shelter, is fitted with adjustable louvres, as shown in the drawing, ensuring efficient distribution of the warm air over the whole of the shelter space. These louvres can be adjusted to give an air stream in almost any direction, and the amount of air emitted from each louvre can be determined by the turning of a small screw. All the heat supplied to the shelter is in the form of warm air. Since the heater unit is external to the shelter, any fracture in the gas mains or electricity connections, it is claimed, can affect no one inside the shelter. A claim made for the unit is that a shelter can be made poison gas-proof. The air inlet to the heater unit can be a stack carried above the probable gas line, and since the air raid shelter is under a slight pressure due to the plenum caused by the heating system, the shelter would be gas-proof except for what might be drawn in through the air inlet stack. During the summer months, when the necessity for heating arises only occasionally, the heater may be used as a simple ventilating unit by turning off the gas supply; also deodorant may be introduced on the delivery side of the heater if desired.



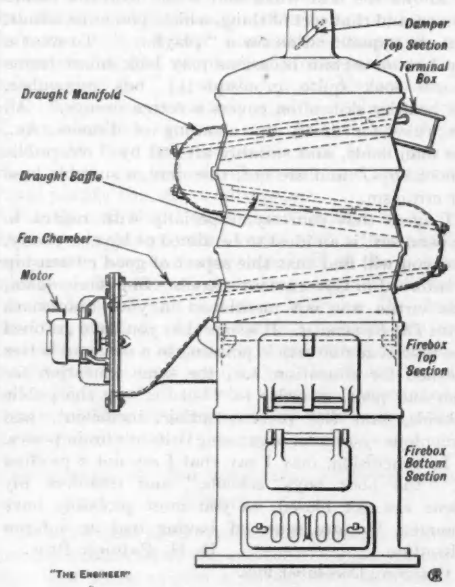

ARRANGEMENT OF SHELTER HEATING SYSTEM

Essentially the heater is a tube type interchanger, fired by a system of bar gas burners of special design. The air tubes, which are welded into end plates of heavy gauge mild steel, are graduated in size from bottom to top to ensure that the maximum thermal efficiency is obtained. False side plates, forming additional air spaces, are incorporated in the design, thus ensuring that the sides of the casing remain cool and improving the thermal efficiency of the apparatus by cutting down the radiation surfaces to an absolute minimum. A collecting box and stack for the waste gases are fitted to the top of the interchanger. On the delivery side of the air tubes the casing is extended and a scroll of normal design is formed, in which is fitted a fan runner of the multi-vane centrifugal type, mounted on the extended spindle of a totally enclosed motor, the motor being fitted external to the casing and mounted on a pedestal attached to the casing. The apparatus is designed to work in conjunction with a thermostat and remote control valve. In addition, a valve may be fitted so that in the event of fan failure the gas supply to the heater is cut off to avoid damage to the air tubes due to overheating. An electrically heated unit has also been designed.

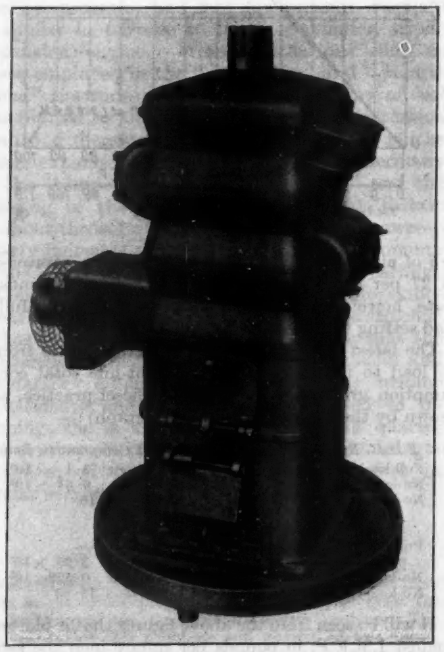
The heaters are made in capacities from 1000 to 7500 cubic feet of air per minute. Any desired temperature rise may be obtained. Standard units are designed for temperature heads of 50 deg., 70 deg. and 100 deg. Fah., respectively.

## "Airflow" Heater

THE accompanying engraving and drawing illustrate the "Airflow" heater made by Tangyes, Ltd., of Birmingham. This heating unit consists of a coke-fired furnace on which are mounted heat exchanger sections. An electric fan blows air through these sections. The warmed air is discharged at high velocity just above the floor at the rate of 400 cubic feet per minute. The heater is capable of an output of between 60,000 and 170,000 B.Th.U. per hour and though, of course, the space which can be heated depends on other factors, such as the type of building and the degree of warmth required, 60,000 cubic feet can, it is suggested, be regarded as an average figure. It consumes between 6 lb. and 18 lb. of coke per hour and the electrical consumption is 2 units in twelve hours. Apart from stoking two or three times a day and the removal of ash, it requires no attention. The fan which propels the air through the unit runs at 2800 r.p.m. and is usually driven by a single-phase A.C. motor. If quiet running is essential a fan running at only 1430 r.p.m. can be supplied, but the output of heated air is then materially reduced. This heater is claimed to have the lowest running cost of any heating system. In hot weather it can be used as a cooling and ventilating unit. It is further to be noted that all Tangye Standard No. 1 stoves made since the beginning of 1939 can be converted to "Airflow" operation, since the heater is a development of that design of stove.




ARRANGEMENT OF "AIRFLOW" HEATER



"AIRFLOW" HEATER

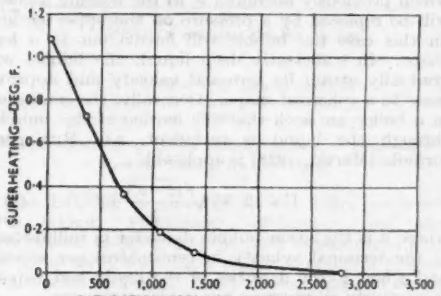
# Steam Generation at High Pressures*

By R. F. DAVIS, M.Sc. (Eng.), M.I. Mech. E.†

## STEAM GENERATION

*Evaporation at a Heated Surface.*—Evaporation from a submerged heated surface may take place either by nuclear boiling, or by film boiling. In nuclear boiling the water evaporates into steam bubble spaces and the water is therefore superheated because the surface tension at the bubble interface raises the internal pressure. Theoretically nuclear boiling cannot originate at an absolutely plane surface, where the initial diameter of a bubble would be infinitely small and the superheating of the water infinitely high; but in a boiler the metallic surface in contact with the water has free binding forces, which may build up small solid particles and gases into layers of from 10 to 20 molecules in thickness. A surface indentation or scratch will accordingly be associated with a highly concentrated mass of adherent particles, and form a nucleus for evaporation if the metal is heated above the boiling point of the liquid (Schmaltz, 1937). Surface irregularities and roughness due to oxide and scale deposits can also become points of nuclear generation for the same reason.

In nuclear boiling it is the slight superheating of the water which provides the impulse for heat transfer from the water to the steam. The amount of this superheating varies with the pressure, and the values found by Jakob (1937), and his co-workers for water in bulk are shown plotted in Fig. 1. Moreover, the amount of superheating decreases with increasing




○ Temperatures observed by Jakob (1937).

**FIG. 1**—*Superheating of Boiling Water*

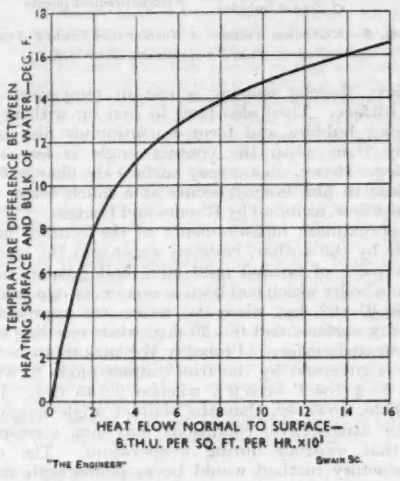
pressure because the surface tension decreases. In close proximity to the heating surface the temperature of the water approaches the temperature of the surface itself.

In nuclear boiling the heat transfer takes place in two stages. First, from the heating surface to the boiling liquid, and second, from the liquid to the surface of the bubbles, from which the liquid evaporates into the bubble (Bosnjakovic, 1930). Since bubbles originate in the more highly superheated layer adjacent to the heating surface they are subjected to a higher temperature in the earlier period of their development than in the later stages. According to Jakob the coefficient of heat transfer across the bubble surface at the moment of origin of the bubble is of the order of 40,000 B.Th.U. per square foot per hour per degree Fahrenheit temperature difference; but this is only momentary and decreases rapidly as the bubble grows in size. When the bubble has detached itself from the heating surface and so left the highly superheated layer, the transmission rate across its surface tends to assume a steady value of about 3000 B.Th.U. per square foot per hour per degree Fahrenheit. The temperature difference is that between the superheated water and the steam in the bubble.

The temperature difference between the heating surface and the water as a whole is affected to a certain extent by the convection or stirring effect of the rising bubbles, and therefore by the number of nuclei per unit area of heating surface and by the frequency with which bubbles form at a given nucleus. Jakob found the coefficient of heat transfer between a heated metal plate and water to vary, not only with the intensity of heating, but also with the condition of the surface—that is, its roughness and whether it had been previously exposed to the atmosphere and had adsorbed air on its surface, also with the length of time it had been in service. Fig. 2 is reproduced from Jakob's results for a horizontal metal surface sand blasted and then oxidised by long use, and probably represents the condition of a boiler plate or tube in service more exactly than other graphs given by the same investigator. Graphs of much the same shape were obtained with a specified heating surface when placed vertically or horizontally.

Once a state of nuclear boiling has been attained at a given place, the steady application of heat at that place results in a uniform rate of bubble formation there, but an increase in the rate of heating gives rise to fresh nuclei because the higher superheating of the water in contact with the heating surface allows vapour bubbles to originate at places of smaller curvature. This process does not, however, continue indefinitely, for, with an increasing rate of heating, a state is eventually attained in which the bubbles become so numerous and closely packed that they coalesce and so form a continuous film of vapour between the heating surface and the liquid. Then evaporation takes place by film boiling, when the vapour leaves the film in the form of large irregular-shaped bubbles.

The change from nuclear to film boiling is well illustrated by the photographs obtained by Drew and Mueller (1937) in their experiments on the boiling of carbon tetrachloride. In the same paper reference is made to the curve for water derived by Nukiyama (1934), which is reproduced in Fig. 3, in order to show the quantitative effect of a progressive increase in the rate of heating. It is clear that the difference of temperature between the heating surface and the water is not very great between the limits defined by nuclear boiling (A to B on the graph). At the point B, however, this law of variation undergoes a sharp change, of a kind such that further increase in the heat flow will actually lead to a decrease in the transmission rate, until the minimum value is reached at C. The




Surface roughened by sand blast and oxidised by use.

**FIG. 2**—*Temperature of Metal Heating Surface (Jakob)*

length B C of the graph is shown dotted because it represents an unstable state in which parts of the vapour film collapse in an irregular manner. Any increase in the rate of heating beyond that corresponding to the point C will cause a gradual increase in the transmission rate (C to D on the graph), but only at the expense of a considerable increase in the metal temperature because the heat will then be transferred across a continuous film of vapour having a relatively low conductivity. Nukiyama derived the foregoing graph from experiments with an electrically heated platinum wire, and it does not follow that the maximum nuclear boiling rate indicated by Fig. 3 would be the same for a boiler plate or tube. There is, indeed, much evidence in support of the view that the maximum rate is influenced considerably by the nature and condition of the heating surface. For instance, Jakob obtained heat flow rates as high as 95,500 B.Th.U. per square foot per hour from a flat, horizontal copper plate, and at this rating nuclear boiling still persisted. Again, with a vertical cylindrical heating surface of the same material, he found that above 74,000 B.Th.U. per square foot per hour the transmission rate from the heating surface to the water decreased with a rapid rise in the metal temperature, which eventually burnt out the electric heating elements. The latter rating for a vertical surface corresponds to the heat flow which results in a boiler tube when subjected to the radiation from a luminous flame at a temperature of about 2300 deg. Fah.

That the condition of the heating surface does have considerable influence on the critical rating, at which the change from nuclear to film boiling occurs, has also been demonstrated by the experiments of Rhodes and Bridges (1938), who found that the wettability of the surface—or, more accurately the contact angle between the liquid and the heating surface—has a profound effect on the critical rating. Relatively small amounts of certain substances in solution or in suspension may also have a great effect in altering the manner of boiling. Evidently the critical rating for a boiler tube or plate will depend on the nature of the boiler water, on the condition of the effective heating surface, and, possibly, on the inclination of the surface.

Normally evaporation in a water-tube boiler takes place by nuclear boiling, since film boiling would obviously involve such high metal temperatures that the tubes would quickly fail by rapid creep or plastic flow of the metal, especially with the high saturation temperatures which accompany high pressures.

In most cases where tube failures have been reported as due to flame impingement, it is possible that either scale or choking of the tubes by sludge deposit has been a contributory cause; but the possibility of overheating of the metal under conditions of film boiling cannot be ruled out entirely until more is known about the subject.

Investigations recently carried out in America by Partridge and Hall (1939) have disclosed a phenomenon analogous to film boiling. This "steam blanketing" has, in the main, been found to occur in the case of boilers operating above 1200 lb. per square inch, and having tubes that are insufficiently inclined to the horizontal. At high rates of heat input, the bubbles collecting at the crown of these nearly flat tubes form an almost continuous insulating steam blanket. The consequent overheating of the metal at the crown of the tube and its intermittent splashing by the relatively colder water resulted in some instances in cracking of the metal, and in others the localised concentration of the boiler water caused erosion. A state of bubble stagnation at the crown of slightly inclined tubes is usually prevented by the circulation of the water. In the majority of the cases mentioned by Partridge and Hall failure occurred in very flat ash or sag screen tubes and the tubes supporting slagging furnace bottoms. One of the conclusions to be drawn from their investigations is that the tubes of high-pressure boilers exposed to high gas temperatures should have an inclination of at least 12½ deg. with the horizontal.

*The Formation of Steam Bubbles at a Heated Surface.*—The initial size of a steam bubble depends on the radius of curvature of its original nucleus, which may be a minute gas bubble, or a particle of sludge or scale adhering to the surface, or a mere roughness on the heating surface. If the initial nucleus is a solid spherical surface it cannot become available for growth until the vapour pressure at that point exceeds the equilibrium state, giving

$$r = \frac{2\gamma}{p_1 - p_0} \quad . \quad . \quad . \quad . \quad . \quad (4)$$

as the minimum nuclear radius available with an external pressure $p_0$ and an internal vapour pressure $p_1$ in a liquid having surface tension $\gamma$. Surfaces

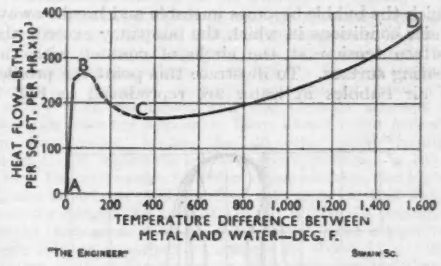



**FIG. 3**—*Boiling Rate and Temperature Difference between Metal and Water at Atmospheric Pressure (Nukiyama)*

with much larger radii of curvature than that given by equation (4) do not become nuclei, because they do not provide the same degree of concentration of vapour molecules per unit of projected area within the same period of time.

If the initial nucleus is a small gas bubble, the conditions will be modified by the partial pressure within the bubble. It can be shown (Newman and Searle, 1933) that a gas bubble becomes available as a nucleus when

$$r = \frac{4}{3}\,\frac{\gamma}{p_1 - p_0} \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Table I, calculated by means of equations (4) and (5), shows the minimum radii of gas bubbles and solid surfaces which become available at different degrees of water superheating under atmospheric conditions:

TABLE I.—*Minimum Radii of Gas Bubbles and Solid Surfaces*

| Superheat of water, deg. Fah. | Radius of gas bubble, microns. | Radius of solid surface, microns. |
|---|---|---|
| 2 | 23 | 35 |
| 4 | 11 | 17 |
| 10 | 4·3 | 6·5 |
| 20 | 2·0 | 3·0 |
| 30 | 1·2 | 1·8 |
| 40 | 0·8 | 1·2 |

It is evident from Figs. 2 and 3 that with nuclear boiling the heating surface is not likely to exceed the temperature of the bulk of the water by more than about 40 deg. Fah., under atmospheric conditions, and the superheating of the water layer in contact with the heating surface must be less than that figure. It will be noted that at 40 deg. Fah. superheat, the dimensions of the available nuclei approach those of particles which form permanent suspensions. This gives some idea of the extreme smallness of the nuclei. At higher pressures, due to the decrease in surface tension, still smaller nuclei become available. Nuclear boiling, therefore, continues to exist at high pressures and with reduction in the degree of superheat (Fig. 2).

* Abstract from a paper entitled "The Physical Aspect of Steam Generation at High Pressures and the Problem of Steam Contamination." Institution of Mechanical Engineers, December 13th, 1940.

† Technical Engineer, International Combustion, Ltd., Derby.

The subsequent shape of the bubble, as it grows in size by evaporation from its surface, is determined by the forces acting upon it. When the heating surface is horizontal and faces upwards, the bubble is symmetrical about its vertical axis, and its shape and size are calculable from considerations of static equilibrium. To illustrate the point, let Fig. 4 represent the axial section of a bubble anchored at the heating surface, A B any horizontal plane

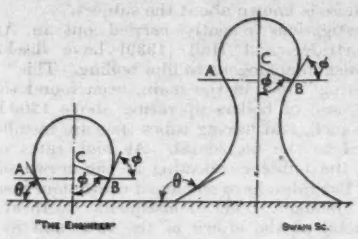



FIG. 4—*Diagram of Formation of Steam Bubble*

drawn through the bubble so that the tangent at A makes an angle $\varphi$ with the horizontal, and let $v$ be the volume of the bubble above A B. If $r_1$ is the radius of curvature in the plane of the diagram, at B, and B C is the normal at B meeting the axis at C, then B C$=r_2$ is the other principal radius of curvature at B. The forces acting at the plane A B under static equilibrium, assuming the external pressure $p_0$ is sensibly uniform over the height of the bubble, are :

Upwards : $p_1 \pi r_2^2 \sin^2 \varphi + (\rho - \rho') v g$
Downwards : $p_0 \pi r_2^2 \sin^2 \varphi + \gamma \sin \varphi \, 2 \pi r_2 \sin \varphi$

which, when equated, give

$$2 \gamma \pi r_2 \sin^2 \varphi = (p_1 - p_0) \pi r_2^2 \sin^2 \varphi + (\rho - \rho') v g.$$

The terms $p_0$ and $p_1$ can be eliminated by combining the above expression with equation (16) in Appendix I (not reprinted), and substituting the contact angle $\theta$ for $\varphi$ in the resulting expression for $v$, to obtain the total volume V of the bubble above the heating surface, in the form

$$V = \frac{\pi \gamma \sin^2 \theta}{(\rho - \rho') g} \left( \frac{1}{r_2} - \frac{1}{r_1} \right) r_2^2 \quad . \quad . \quad . \quad (6)$$

Although the angle of contact has no influence on the shape of the bubble above the surface, it nevertheless determines the maximum volume above which the bubble becomes unstable and breaks away, under conditions in which the buoyancy exceeds the surface tension at the circle of contact with the heating surface. To illustrate this point the profiles of air bubbles in water are reproduced in Fig. 5

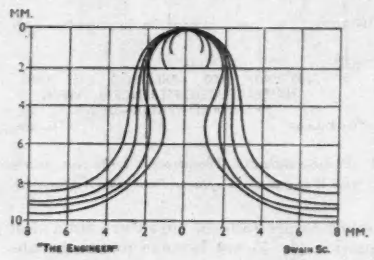



FIG. 5—*Shapes and Sizes of Stationary Air Bubbles in Water (Wark, 1933)*

for different initial radii of curvature. These are mostly shown for the limiting value of $\theta = 180$ deg.; for lesser values of the contact angle a separate horizontal line must be drawn through each profile, so that each profile meets each line at the correct contact angle.

To determine the shape of a bubble and its maximum volume requires special methods of analysis, which Jakob and his co-workers, following the method of Wark, have reduced to a simple curve (reproduced in Fig. 6) connecting the contact angle $\theta$ with the dimensionless expression $(V/a^3)^{\frac{1}{3}}$, where V is the maximum volume and

$$a = \sqrt{\frac{2\gamma}{(\rho - \rho') g}} \quad . \quad . \quad . \quad . \quad (7)$$

This curve has been checked by Jakob for water over the range of contact angles $\theta$ from 20 deg. to 100 deg. by measuring the photographs of bubbles in the process of formation. Considering that the real problem is dynamical and not statical, as assumed in the theoretical analysis, the agreement is remarkably close.

Combining equation (7) with equation (3) and using the straight-line relationship of Fig. 6 between $\theta$ and $(V/a^3)^{\frac{1}{3}}$, a very simple formula can be established for the mean diameter of the steam bubbles leaving a horizontal heating surface, namely,

$$d = \frac{\theta}{17 \cdot 8} (\rho - \rho')^{1 \cdot 5} \quad . \quad . \quad . \quad . \quad (8)$$

where $d$ is the mean diameter (with respect to volume) of the bubbles in millimetres, $\theta$ is the contact angle in degrees, and $\rho$ and $\rho'$ are the densities of the liquid and vapour respectively in grammes per cubic centimetre. By means of equation (8) the chart shown in Fig. 7 has been prepared to show the mean diameter of steam bubbles released from a horizontal heating surface over the complete range of the saturation pressure of steam, and for contact angles from zero to 90 deg.

The contact angle only equals or exceeds 90 deg. with a very smooth or a greasy surface. In the case of contact angles greater than 90 deg., the bubbles are liable to take up a re-entrant shape, as in Fig. 4, and break away at the narrowest section of the neck, where it is nearly cylindrical, and the volume of the released portion is the same as if the contact angle were 90 deg. Bubbles of a re-entrant shape have a considerable area of contact with the heating

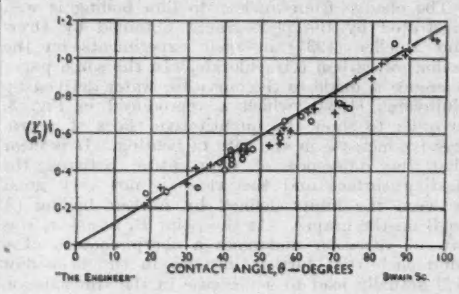
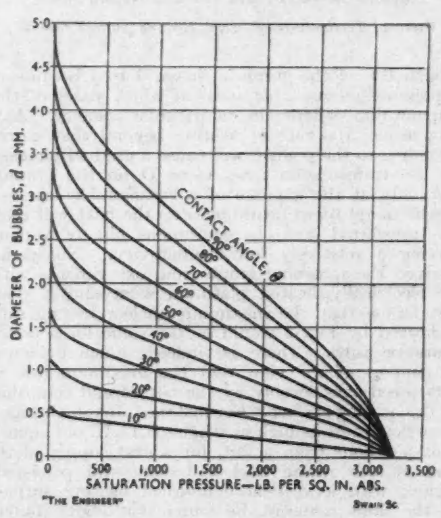



FIG. 6—*Maximum Volume of Bubbles and Contact Angle, According to Fritz's Calculation (after Jakob)*

surface, thereby causing a rise in temperature of the surface. They also tend to join up with neighbouring bubbles and form a continuous film more easily than when the contact angle is less than 90 deg. Hence, at a greasy surface the change from nuclear to film boiling occurs at a much lower rate of heat flow, as found by Rhodes and Bridges.

Approximate measurements of the contact angle made by the author, between water and the surface of a piece of normal mild steel boiler tube, taken from a boiler which had been in service, gave a contact angle $\theta'' = 62$ deg. when the water was approaching the dry surface, and $\theta' = 20$ deg. when receding from the wetted surface. Probably the maximum bubble size is governed by the true contact angle $\theta$, where $\cos \theta = \frac{1}{2} (\cos \theta'' + \cos \theta')$, whence $\theta = 45$ deg. It is possible, however, that the contact angle measured under atmospheric conditions may not correspond to that existing during evaporation. The only satisfactory method would be to photograph steam




$$d = \frac{\theta}{17 \cdot 8} (\rho - \rho')^{1 \cdot 5}$$

FIG. 7—*Mean Diameter of Steam Bubbles Leaving a Horizontal Heating Surface*

bubbles in the process of formation; so far this has not been recorded for boiler water in contact with steel that has been in service, but provisionally it may be assumed that in a boiler the contact angle is about 45 deg.

It has been demonstrated that in the case of a horizontal heating surface facing upwards the size of the steam bubbles at release is calculable, within limits, and varies with the boiler pressure and, to some extent, with the nature of the boiler water and the condition of the heating surface. In practice, heating surfaces have non-uniform inclinations, and the size of bubbles at release, though observable, is not amenable to mathematical treatment. For a heating surface facing upwards, however, the size of the bubbles released does not change to any appreciable extent between the limits of the horizontal and vertical positions of the surface; but when the surface is facing downwards the results are different. The more nearly horizontal the surface is, the larger the bubbles become before being released, and they tend to flatten out against it, causing, in the extreme case, steam blanketing and possible overheating of the metal.

In the tubes of a water-tube boiler, the bubbles are subjected, in addition to their buoyancy, to a transverse shearing force imparted by the flow of the water along the tube. Bubbles are thus torn off the heating surface more quickly and are therefore smaller in size than if detached by the action of buoyancy alone. In a water-tube boiler, therefore, at release from the heating surface, some bubbles will be larger and some will be smaller than indicated by Fig. 7, depending on the velocity of circulation in each tube, and the slope and aspect of each individual portion of the heating surface.

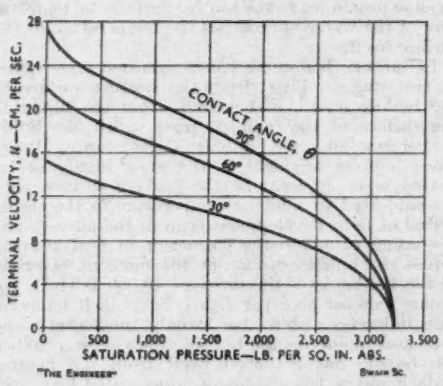
*The Migration of Steam Bubbles from the Heating Surface to the Free Water Level.*—At the instant of release of each bubble from its circle of contact with the heating surface, the narrow cylindrical neck which forms between the base of the bubble and the heating surface, rapidly elongates and closes in, with an impact, causing a sound wave. The characteristic noise associated with ebullition is produced by a succession of these minute impacts, which occur with a momentum that largely depends on the viscosity of the liquid. At higher saturation pressures the viscosity of water diminishes (Sigwart, 1936), and therefore the suddenness with which bubbles are released increases. The frequency of release from a given nucleus will also increase with the saturation pressure, and, according to Jakob's experiments, will be inversely proportional to the bubble diameter.

Immediately a bubble is released it will commence to rise, on account of its buoyancy, at an increasing speed, and the downward pull of the surface tension, which previously anchored it to the heating surface, will be replaced by a pressure on the upper surface. In this case the bubble will flatten out to a lens shape. In sufficiently deep liquid, the bubble will gradually attain its terminal velocity and approximate to a spherical shape. Generally, the conditions in a boiler are such that the motion of the bubbles through the liquid is turbulent, and Rittinger's formula (Martin, 1928) is applicable :

$$U = 12 \cdot 35 \sqrt{\frac{(\rho - \rho')}{\rho} d} \quad . \quad . \quad (9)$$

where $d$ is the mean bubble diameter in millimetres, U the terminal velocity in centimetres per second, and $\rho$ and $\rho'$ the densities of the liquid and vapour respectively in grammes per cubic centimetre.

Fig 8 shows the calculated terminal velocities for bubbles leaving horizontal heating surfaces with contact angles of 30 deg., 60 deg., and 90 deg., and having mean diameters according to Fig. 7. Equation (9) is based on the assumption of a single bubble moving in an extensive field of liquid, and Jakob




$$U = 12 \cdot 35 \sqrt{\frac{(\rho - \rho')}{\rho} d}$$

FIG. 8—*Terminal Velocity of Steam Bubbles Leaving a Horizontal Heating Surface*

records a mean velocity of 26 cm. per second for bubbles from 1 mm. to 8 mm. in diameter; this agrees fairly well with equation (9), which for the same range of sizes gives a mean velocity of 24 cm. per second. On the other hand, Behringer (1934) found that when the bubbles are closely packed in a tube, they rise at considerably greater velocities, as indicated by the curves in Fig. 9, which are reproduced from his experimental results.

Behringer's results merit close consideration, because in a water-tube boiler the size and relative velocity of the bubbles control the circulation and, to some extent, the quality of the steam, Behringer explains the increase in the relative velocity of the steam and water with increase in the proportion of steam, as due to the mass effect of the closely packed bubbles and the entrained liquid. Yet an exactly opposite phenomenon occurs with a cloud of solid particles moving through a liquid; it is well known that the rate of sedimentation of solid particles decreases with increase in the concentration. It is strange, therefore, that bubbles seemingly behave in a contrary manner; the more concentrated they are, the faster they move, and it is just possible that Behringer's explanation is not correct.

The tube which Behringer used was totally enclosed, and presumably he had no means by which he could see what was happening inside it. Brooks and Badger (1937), experimenting with a long glass tube heated throughout its length, observed that the bubbles coalesced, pushing ahead of them slugs of liquid, which subsequently became thinner by evaporation and finally broke, allowing the vapour to pass through them. Annular rings of liquid then appeared, and spread over the walls, in the form of an irregular film.

Although the tube used by Behringer was not heated throughout its length, as in Brooks and Badger's experiments, it is nevertheless probable that some

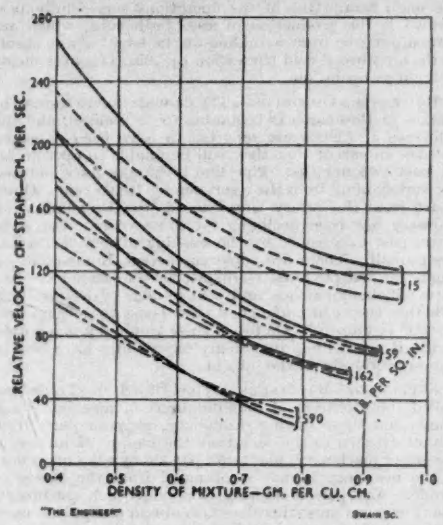



FIG. 9—*Velocity of Steam Bubbles relative to Water in a Vertical Tube (after Behringer)*

of the bubbles, in passing up the tube, coalesced with others. Presumably, Behringer, and also Brooks and Badger, used in their experiments pure water, or water containing only a very small proportion of dissolved salts. The bubbles in pure or nearly pure water will easily coalesce, and because of this pure water will neither aerate nor foam. It is extremely likely, then, that coalescence did occur in Behringer's steel tube, as was observed in Brooks and Badger's glass tube.

*(To be continued)*

## TECHNICAL REPORTS

*Precautions for Concreting and Bricklaying in Cold Weather: War-time Building Bulletin No.* 11, *D.S.I.R.* H.M. Stationery Office. Price 1s.—Concreting and bricklaying are affected by cold weather in two principal ways:

(*a*) The mixes harden more slowly than at normal temperatures.

(*b*) The water in mortar or concrete mixes may freeze.

What must be done to avoid trouble with concrete depends on how severe the conditions are, but for average winter weather simple precautions are enough. For instance, concreting should not be undertaken if the air temperature falls below certain limits, and when concreting has stopped the concrete should be covered and protected. Aggregates and mixing plants will need shelter. For very urgent work which has to be carried on regardless of extremes of weather more drastic precautions are needed, and for these the Building Research Station has drawn largely on experience in Canada and the United States. For example, preheating of materials and the heating of equipment and formwork will be needed, and even after it is deposited, concrete will often require heat during the initial stages of setting. Details of the equipment needed and the temperatures to be worked to are all given in the *Bulletin*. A guide for the stripping of formwork is also given and notes on the use of calcium chloride are included.

Brickwork must be treated in much the same way as concrete, but special precautions in mixing and using mortars are mentioned.

COMPRESSED MAGNESIA.—The properties of compressed magnesia as an electrical insulator for reasonably high voltages have been investigated at the University of Wisconsin, Madison, Wisconsin. By applying a pressure of about 6500 lb. per square inch wafers of compressed magnesium oxide can be made, the electric strength of which, both for A.C. and D.C. voltages, is about 300 kV per centimetre. Compressed magnesium oxide, if unconditioned, has a certain moisture content which for lower frequencies causes a large power factor. If the oxide is first heated to 160 deg. Cent., however, the moisture is removed, and the power factor at room temperature drops to about 0·002 for both lower and radio frequencies. The compressed powder has a high porosity factor, about 67 per cent. The high electrical strength, even of the unconditioned material, is attributed by the investigators to its inorganic nature, which results in the compressed oxide being strongly resistant to overheating, due to conduction currents, and local ionisation which certainly occurs at high weld strengths.

# Markets, Notes and News

**The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer**

### Aluminium Alloy Scrap

It is common knowledge in the light alloy industry that there is a considerable difference of opinion as to suggestions which have been made to enforce the artificial classification of light alloys as primary or secondary according to whether they are produced from virgin metal or contain appreciable quantities of high-grade scrap. Probably the majority of the industry is antagonistic to this proposal. The latest contribution on the subject is from Mr. H. F. James, a director of the Northern Aluminium Company, Ltd., who, in a statement, points out that as a result of the urgent need for increasing the output of British aircraft, the most efficient utilisation of all available supplies of aluminium is a matter of the greatest importance. The most remunerative step in this direction is to ensure that all good quality aluminium alloy scrap is recovered in an identifiable form for further use. Several British Standard Specifications relating to aluminium alloy products for aircraft construction have recently been relaxed in order to permit the use of scrap other than that of a manufacturer's own production. These modifications removed the sole remaining dividing line between the so-called "virgin" and "secondary" alloys. For some years this division has been somewhat fallacious except in the case of materials required to conform rigidly to British Standard Specifications. The increasing care taken in the segregation and remelting of light alloy scrap has permitted the introduction of much larger proportions of such scrap into good quality alloys. There are now no high quality aircraft alloys in which scrap is not or cannot be used. There is no doubt that, so long as unwanted constituents in scrap are kept within the required limits by careful sorting and melting in clean furnaces under satisfactory conditions, the product is, in all respects, suitable for addition to melts consisting of virgin metal and production scrap from semi-finished forms such as, for example, aluminium alloy sheets. Before these were introduced a danger existed that the practice might continue of de-grading high quality scrap such as duralumin sheet cuttings by adding it to melts containing zinc, iron, silicon, or other impurities in order to produce low-grade casting alloys. This would, of course, have resulted in a loss of aluminium for aircraft production of several thousand tons a year. Immediately upon the outbreak of war, the use of aluminium was severely curtailed, and it became obvious that all good quality scrap should be segregated and used again in melts of composition similar to that of the original sheet, rod, or other material from which it was produced. Utilised in this manner its intrinsic value is approximately equivalent to that of alloys of similar constitution produced from virgin materials. The percentage of such secondary material that can be added to melts is limited only by the supplies of segregated scrap available.

### The Pig Iron Market

The pig iron position in Great Britain can be regarded as comfortable, and although there has been an increased demand, principally from the foundry section of the market, it does not seem to have been sufficient to throw any additional strain upon the producers. Market activity is not greatly in evidence, but this presumably will develop as consumers place their orders for the pig iron they have been allocated for the first quarter of next year. At the moment it would appear that whilst many users have already contracted for material well into 1941 there are still a large number who have not received their allocations, or have delayed arranging their deliveries. The light castings industry has more work in hand than for some time and is taking up larger supplies of foundry iron. The demand, however, is not of such proportions as to necessitate an increase in the output of foundry qualities, while the availability of plentiful supplies of cast iron scrap also helps to limit the requirements of the foundry iron producers. On the North-East Coast it is generally understood that there is no intention of increasing the production of foundry grades, but consumers in the district are receiving sufficient pig iron from the Midlands to meet their full requirements. Most of the blast-furnaces on the North-East Coast are busily engaged in producing basic iron for the steel works whose demands are naturally on an extensive scale. In the Midlands there is a heavy demand for foundry iron from the engineering establishments, whilst the jobbing foundries and machine tool makers are also taking up large supplies. For the time being there is no stringency in the foundry iron market, either in the case of low or high-phosphoric qualities. The situation in Scotland shows little change. The requirements of the consuming industries are well looked after. The demand from the light castings industry is still rather poor, but it is anticipated that this will expand as more light castings foundries are put upon war work.

### The Midlands and South Wales

There has been no slackening in activity at the Midland steel plants. The demand for certain heavy sizes of joists and sections may have fallen off a little, but increased requirements for other descriptions have more than counterbalanced any decline. In the aggregate the demand is probably heavier now than at any time since the war commenced. But for the careful supervision exercised by the Iron and Steel Control the satisfaction of consumers' requirements would undoubtedly present a more serious problem. In many cases works are fully booked for the first quarter of 1941, but as they are working under priority instructions they are relieved from a certain amount of responsibility. The munition makers are absorbing large tonnages of special steels, and the output of shell steel has reached a high level. The plate position has become rather tight, particularly if there is any question of early delivery. The shipyards are taking large quantities, and other users, such as wagon builders and tank makers, are absorbing important tonnages. There have been considerable imports of finished steel from the United States, and these are also being used by consumers in all parts of the country. Business in bright drawn steel bars seems to be increasing, and the makers report that the orders on their books will take some weeks to execute. A large business is passing in colliery steel, but supplies seem adequate to meet requirements. Market reports from Wales indicate that there is an increasing demand for plates, whilst the heavier joists and sections are not required in such large tonnages as a short time ago. The supplies of sheet and tin-plate bars seem equal to the pressing demand, although deliveries to the works are rationed.

### Scotland and the North

The pressure under which the steel works in Scotland have been operating for some time shows no signs of relaxing. Outputs have been on an extremely heavy scale and the order books of most of the works are in a congested state. In fact, the mills are fully booked well into 1941, and there is little prospect that the demand will decline. No doubt at times the volume of new business may fall off, as, for instance, was the case recently when a large number of consumers were able to book their requirements for some weeks ahead. Naturally, a lull in the demand followad, but this was of comparatively short duration, and afforded small relief to the steel works which were struggling to overtake arrears. The war requirements of the country continue to absorb probably nine-tenths of the production of most iron and steel products. The pressure to obtain plates of all thicknesses has not slackened, and large tonnages are passing to the shipyards, which have a heavy programme of work in hand. The tank makers and boilermakers are also busy, and their needs in the aggregate reach a big total. The quantities of joists and other structural material passing into consumption are still large, although not so important as was the case a few months ago. This class of steel, however, forms a considerable proportion of the production. The Scottish marine engineers have full order books, and their requirements of many descriptions of steel are particularly heavy. The Scottish tube industry has been engaged to capacity for a long time and the demand shows no signs of diminishing. In Lancashire busy conditions rule in the iron and steel industry, and, as in other producing districts, the demand for plates is an outstanding feature of the situation. On the North-West Coast all the steel works are fully employed and there is a considerable production of rails, hoop, and strip.

### Copper and Tin

The copper position has not materially changed over the week. In Great Britain there appears to be plenty of copper for firms engaged upon war industries, but apparently there is not much surplus for non-essential purposes. Supplies, however, continue to reach this country with regularity, and the German attempt at blockade does not appear to have affected the arrivals. In the United States the domestic price remains at 12 c. d/d, whilst the official export quotation is 10½ c. f.a.s. The latter price, however, seems variable, and higher figures have been paid; in fact, it is reported that Japan recently bought 500 tons at 11½ c. Whilst the producers retain their price at 12 c., some second-hand copper has been sold to American consumers at above 12 c. The system of allocating copper to their customers is followed by the American producers. It is possible to obtain copper in America from merchants, but the market is uncertain, and apparently the metal can only be obtained this way in "bits and pieces." In November the American production of refined copper increased by 13,000 tons to 96,283 tons. At the end of November the stocks totalled 158,418 tons, or 6000 tons less than at the end of October, when the total was 164,618 tons. . . . The tin market in Great Britain has been rather lifeless, and price movements have been almost negligible. The position appears to rest largely upon the United States, where it is understood considerable stocks exist. Although it was assumed that American buying might cause the price to rise, when recently the United States Government bought a fair quantity, it had not the slightest effect upon the market here.

### Lead and Spelter

Large tonnages of lead continue to pass into consumption principally for war purposes. Supplies to Great Britain have been well maintained, and the full requirements of the war industries have been met. A surplus appears to be available also for firms producing exportable products. It is possible that as a result of war damage to property, civilian requirements may become larger. There seems to be plenty of metal available, although naturally the Control restricts its use on unessential needs to a minimum. Probably the largest consumers are the battery and cable makers, and a considerable tonnage is passing into consumption in these industries. In the United States the domestic price remains at 5.50 c., New York. The position in that country appears to be somewhat stringent, and if consumption continues to expand, which it may well do under the influence of the American armament programme, there seems a doubt whether the United States domestic output will be sufficient to meet requirements. This, however, could be easily rectified by the importation of lead from Mexico. . . . . The world spelter market continues rather tight, and in Great Britain whilst there is sufficient metal to meet the war demands, there is little available for other purposes. In fact, in spite of the world position, in Great Britain the situation appears to be comfortable. Apparently, stocks are limited, and the Control naturally discourages the use of spelter for anything but essential purposes. Recently there has been some speculation as to the position of spelter in Italy. Before the war the Italian production was only sufficient to provide for that country's peace-time needs. Obviously war requirements will cause a considerable expansion in the demand.

# Notes and Memoranda

## Rail and Road

A LOCOMOTIVE ORDER.—The Chilean State Railways have taken delivery of eleven steam locomotives manufactured by the Baldwin Locomotive Works.

WOOD FOR FUEL.—A number of divisions of the Swedish State Railways will equip steam locomotives for burning wood fuel in view of the necessity of reducing coal consumption in the country during the coming winter.

TRAIN SCRAP.—The amount of scrap collected from and arising from the use of, trains is considerable. During the past three months the L.M.S. Railway has collected 4045 tons of waste of all descriptions. Included in this total are scrap metal (2193 tons), waste paper (1287 tons), as well as 65,706 bottles.

ANTI-FREEZE MIXTURES.—The Ministry of Transport has been informed that the supplies of anti-freeze mixtures available for motor vehicles should be sufficient to meet all essential needs, provided that these mixtures are not used unnecessarily. The importance of taking precautions against frost without delay is again stressed by the Ministry, as damaged parts cannot easily be replaced.

TO SPEED UP RETURNS.—A publicity campaign, to impress rail transport users with the need for speedy off-loading of railway wagons, has been proposed by Captain Poole, and is to receive consideration from Colonel Moore-Brabazon, Minister for Transport. The Minister has also promised not to overlook another suggestion that more coal might be transported by canal than is being so shipped at present.

HOLDING UP ROLLING STOCK.—The Minister of Transport is not the only person concerned about the demurrage of trucks. The German authorities have recently warned the public that goods wagons can only fulfil their purpose while they are being moved. Every hour in which they remain unused—it does not matter whether the wagon is standing empty or loaded—means the waste of valuable loading space, and unnecessary delay in the circulation of freight.

WORK IN NEW ZEALAND.—Work on the South Island main trunk line from Picton to Christchurch has been held up by enlistments of labour, but it is expected that the opening of the line to through traffic will take place early in 1942. Meantimé progress has been advanced a further stage with the completion of the Hapuka bridge near Kaikoura. Twelve months were required for building this bridge, which is of reinforced concrete, and has a length of 1507ft., and the piers were sunk to 23ft. below water level.

RAILCARS.—The Buenos Aires and Pacific Railway has recently added twelve Ganz-built rail motor-cars to its rolling stock. Eight of the cars will be used for passenger traffic, while the remaining four will be used for express and mail traffic out of Villa Mercedes to various branch lines. The cars have a maximum speed of 60 m.p.h. and a normal operating speed of 56 m.p.h. The passenger-carrying units have a seating capacity of sixty persons, while the express cars are so constructed as to permit easy conversion to passenger-carrying facilities if necessary at a later date.

GAS GENERATORS FOR VEHICLES.—Sweden, cut off from easy supplies of petrol and coal, is turning to the design of wood-gas or charcoal-gas generators. Plans are being made to increase the supply of charcoal. Wood resources are plentiful, and charcoal making has old traditions, for it was the fuel used for centuries in the Swedish production of high-grade iron and steel. A consumers' co-operative organisation has begun to collaborate in the production of charcoal by setting up a works and arranging for production in small plants all over the country.

ROAD ACROSS THE ROOF OF THE WORLD.—A motor road across the Pamir Mountains, the so-called "roof of the world," has recently been opened to traffic. The road, which is 352 miles long, links the town of Khorog with Stalinabad, the capital of the Soviet republic of Tajikistan (Central Asia). It was built in 100 days by 22,000 collective farmers of the republic, and crosses the Khabu-Rabad Pass in the Pamirs at an altitude of 3300 m. above sea level. Formerly supplies were carried to the districts through which the road runs by camels, horses, and aeroplanes, and then only in the short summer of three months. Now motor services will be maintained along the new highway throughout the year. The new road opens up prospects for the exploitation of the immense natural resources of the Pamirs.

## Air and Water

EXPANSION IN SWEDEN.—The Eriksberg shipyard is constructing new stocks for big vessels, particularly tankers, up to 16,000 deadweight tons. An extension of plant is also necessary in the electric welding department, which requires space and is steadily gaining importance.

MERCANTILE LOSSES.—Mercantile losses due to enemy action for the week ended December, 8th-9th, 1940: British, 19 ships, total tonnage 86,740; allied, 3 ships, total tonnage 12,937; and neutral, one ship of 1513 tons, making a total of 101,190 tons. The Germans claimed to have sunk during the same period 242,947 tons of merchant shipping.

SEABORNE FOODSTUFFS.—The third annual report of the Research Committee appointed by the Association of Marine Underwriters in British Columbia on the subject of marine moisture damage has been issued. Among other matters considered is the rusting of canned goods. It is admitted now that condensation damage appears to be confined to goods loaded in cold weather and later exposed to warm air, and it is therefore a seasonal problem. Experiments with reference to the lacquering of tins show that plain cans, with no protective coating on the tin-plate, develop the greatest amount of rust damage. If the cans were enamelled on the top and bottom the rust was 58 per cent. less than in the case of plain cans, whilst cans completely lacquered showed 86 per cent. less rust than plain cans.

MOTORSHIPS FOR SWEDEN.—The Rederiaktiebolaget Transatlantic has ordered from the Götaverken shipyard a motorship of 9200 deadweight tons, for delivery in 1941. The vessel is intended for traffic on the company's line between Pacific ports and Australia. It will be equipped with a Götaverken engine developing 4200 S.H.P., calculated to give a speed of 14 knots.

COALING AT GOOLE.—At this port an unusual method has been developed for coaling ships. At the collieries coal is loaded into what are known as compartment boats or floating wagons, which are towed down to the port of shipment, where they are hoisted out of the water and emptied into the steamer. These square steel compartment boats have a capacity up to 40 tons and are towed by steam tugs in trains of twenty.

SHIPBUILDING PLANS FOR INDIA.—A non-official resolution asking the Government of Bengal to move the Government of India to establish, as early as possible, a shipbuilding industry in Bengal, has been passed in the Bengal Legislative Council recently. Mr. H. S. Suhrawardy, Minister of Labour and Commerce, who said that the Government had every sympathy with the spirit underlying the resolution, added that the Scindia Steam Navigation Company had selected Vizagapatam instead of Calcutta as a site for a new shipyard.

STAINLESS STEELS FOR SEAPLANES.—In a long article on British practice in stainless steels in the December issue of the *Edgar Allen News*, particulars are furnished of a grade specially suitable for use for highly stressed parts of seaplanes and flying-boats. Steel No. 4 is a high-chromium, low-nickel stainless steel, with a maximum stress figure of 55–60 tons per square inch. The steel can be heat treated to give a yield of approximately 80 per cent. elongation 15 per cent. minimum, and Izod impact 25ft. lb. minimum. It is specially designed for purposes where a high-tensile steel is required, together with resistance to corrosion.

OIL FROM COAL.—Mr. D. R. Grenfell, Secretary for Mines, in an article written for the annual bunkering section of the *Shipping World*, expressed the view that the next few years may witness very rapid development of "oil from coal" processes. We must prepare for extensive change in detail, but we shall not be justified in departing from the basis of our combined industrial system in which manufacture and transport have been built upon an abundant supply of fuel and power. No country commands either so large a supply of coal in proportion to population or has distributed so widely throughout the world the benefits of this source of heat and power. The future is difficult to forecast, but the outlook for coal and ships is beyond mere speculation.

## Miscellanea

VANADIUM IN GERMANY.—The production in Germany of vanadium from blast-furnace slag has been greatly increased since the outbreak of war, and, according to a United States consular report, the country's requirements of the metal can now be supplied in the country.

GRINDING AID IN BALL MILLS.—After the testing of hundreds of the newer organic chemicals, it has been shown that some wetting and dispersing agents are effective grinding aids in the production of finely powdered cement in ball mills. A mixture containing lignin sulphonic acid has been found a particularly useful product, and is being produced on the commercial scale.

FLEXIBLE GLASS SUBSTITUTE.—We have received from James Clark and Eaton, Ltd., of Scoresby House, Glasshill Street, London, S.E.1, a small sample of "Luxoid," a flexible glass substitute. It is intended as a replacement for glass, and consists of woven glass fibres impregnated with synthetic resin, $\frac{1}{8}$in. thick. The material is translucent, light diffusing, and weatherproof. According to its makers, it is safe enough in ordinary window sizes to resist wind pressure, and if dislodged by blast will usually come away in one piece. It does not break like glass, but tears in the manner of cloth, and it can be cut with a sharp knife.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—In order to comply with the by-laws a formal ordinary meeting of the Institution of Electrical Engineers will be held on January 2nd, at 12.30 p.m., for the suspension of a list of applicants for election and transfer approved by the Council for ballot. The Council has decided that under prevailing conditions it would be inadvisable to hold meetings of the Institution in London during the second half of the session. Particulars of the papers that would have been included in the programme will be published in the January issue of the *Journal*, so that applications for advance copies can be made to the Secretary at the appropriate time by those members who contemplate the submission of written contributions for publication in the form of discussion in the *Journal*.

NEW BRITISH CHEMICAL STANDARDS.—The Bureau of Analysed Samples, Ltd., whose business has been transferred from Middlesbrough to Markington, near Harrogate, announces the following new analytically standardised samples:—*Ferro-manganese No.* 208.—This sample is typical of the type manufactured in blast-furnaces in this country and is particularly useful as a standard for manganese and phosphorus. The accurate determination of phosphorus in ferro-manganese calls for certain precautions peculiar to this type of alloy. Details will be found on the certificate of analyses. *Stainless Steel No.* 209.—This sample is of the 18:8 type incorporating titanium. The certificate of analyses includes modern methods for the determination of Cr, Ti and Mn. Each sample has been analysed by experienced chemists representing well-known manufacturers as well as independent chemists and users, including (in the case of the stainless steel) the Ministry of Aircraft Production. Each bottle of standard material will be provided with a certificate of analyses showing each co-operating chemist's figures, including an outline of the methods he used. Supplies may be obtained from the Bureau of Analysed Samples, Ltd., at its new address or through the usual laboratory furnishers.

A VERY LARGE PRESS.—What is claimed to be the largest of its type in America, a 1700-ton double-slide hydraulic press has been constructed by the Lake Erie Engineering Corporation, Buffalo, N.Y. It is designed to exert a pressure of 900 tons on the blank holder and 800 tons on the main ram. One of the operations successfully performed is the production of steel bath tubs, which are turned out free from wrinkling at the edges of the sheet. Baths are formed cold from 65in. by 79in. 14-gauge sheets in a single operation.

ROUMANIA'S OILFIELDS.—The damage due to the earthquakes in Roumania is beginning to be realised, and the refineries at Ploesti are reported to have been damaged to such an extent that they will be unable to operate for at least two months. Pipe line breakages have reduced the supply of oil from the reservoirs by 15 per cent. Quite apart from the injury thus caused, the Roumanian oil industry has been declining for some years. For some years past expansion, by the opening of new fields, has been small. There are some competent Roumanian oil engineers, but far fewer Germans, for the latter have had little oilfield experience, and next to none of deep drilling. Whether they can make good their boast to develop production is doubtful. On top of these troubles it is reported in the Russian Press that many serious fires have broken out mysteriously in the oilfield.

SUPPLY OF MACHINERY.—The Board of Trade has called the attention of manufacturers of machinery and plant, and those buying machinery, plant or parts from manufacturers, to the fact that the supply of numerous classes of machinery, plant and parts may take place only if the necessary licence is obtained from the Board of Trade. Any person desiring to acquire such machinery, plant or parts must therefore first obtain a supply licence, and manufacturers should make sure that the person proposing to acquire the machinery or plant has a licence. On October 30th a company was convicted of an offence against paragraph 1 of the Machinery and Plant (Control) Order, 1940, for supplying machinery to a person not authorised to acquire such machinery by virtue of a licence granted by the Board of Trade, and was fined £20 and ordered to pay thirty guineas costs. The relevant Board of Trade requirements are set out in Statutory Rules and Orders, 1940, Nos. 875 and 1363, which are obtainable from the Stationery Office. The latter Order gives the list of machinery for which licences are necessary. The operation of the Order is further explained in the *Board of Trade Journal* of August 1st, 1940, which also contains the list of machinery and plant affected. The Orders apply also to second-hand and imported machinery and plant. Application for licences should be made to the Industrial Supplies Department (Machinery Licences Division), Board of Trade, 25, Southampton Buildings, Chancery Lane, London, W.C.2.

## Personal and Business

HENRY HUGHES AND SON, Ltd., have opened a branch at 14, Harrington Street, Liverpool.

MR. LESLIE GAMAGE, director and secretary of the General Electric Company, Ltd., has been elected President of the Chartered Institute of Secretaries.

MR. E. D. MERYON, who has recently retired from the Royal Corps of Naval Constructors, has joined the staff of the Shipbuilding Conference as assistant to Captain Crease, C.B., C.B.E., R.N. (Retd.).

MR. J. LLOYD BENTLEY, of Dorman Long and Co., and formerly of Darlington Forge, has been appointed manager of Wolsingham Steel Company, Ltd., from January 1st. He was originally with Cammell Laird and Co.

GUEST KEEN BALDWINS IRON AND STEEL COMPANY, Ltd., announces that Mr. J. S. Hollings has been appointed vice-chairman and that Messrs. W. F. Cartwright, E. J. Pode, and C. R. Wheeler have been elected to the board of directors.

PRAT-DANIEL (STANMORE), Ltd., of Dalston Gardens, Stanmore, Middlesex, will continue the business of makers of fans, hitherto carried on by Prat-Daniel, Ltd. Due to circumstances arising out of the international position, it has become necessary to liquidate the latter company. The new company will be entirely British both as regards capital and management.

# Forthcoming Engagements

*Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the* TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

**1941**

**Institution of Chemical Engineers**

*Tuesday, Jan. 14th.*—Geological Society's Rooms, Burlington House, Piccadilly, W.1. "Modern Developments in the Design of Plant for the Concentration of Sulphuric Acid," P. Parrish. 2.30 p.m.

**Institution of Mechanical Engineers**

*Friday, Jan. 3rd.*—Storey's Gate, Westminster, S.W.1. "The Control of Oil Fires," A. F. Dabell. 2 p.m.